DEFINITION OF EMBRYOLOGY

- Embryology: - It is the study of the development of an individual before birth (Prenatal period).

- Embryo- It is the developing individual during the first 3 month or 12 weeks of intrauterine life.

- Fetus- It is the developing individual from the 4^{th} month of intrauterine life to the time of birth.

- Development before birth is called **Prenatal development**, and that after birth is called **Postnatal development.**

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Gonads- They are the sex organs that produce sex cells or gametes. The testies is the male gonad and the ovary is the female gonads . Male gametes are called spermatozoa. Female gametes are called Ova.

Fertilization- It is the process of fusion of male and female gametes. It takes place in the uterine tube of female genital tract.

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DEFINITION OF EMBRYOLOGY

It is the science that deals with the process and regulation in the prenatal growth and development of an organism in the female genital tract.

Branches of embryology

General embryology- It is the study of development during pre-embryonic and embryonic periods. During this period ,the single celled zygote is converted by cell multiplication & migration into a miniature form of an individual with various organs and organs system of the body.

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Systemic embryology- It is detailed study of formation of primordia and their structrural and early functional organization into various organs and system of the body.

Ex-Cardio vascular system, Digestive system,Urinary system.

Comparative embryology- it is the study of embryo in different species of animals.

Teratology- this is a branch of embryology that deals with abnormal embryonic and fetal development , congenital abnormalities or birth defects.

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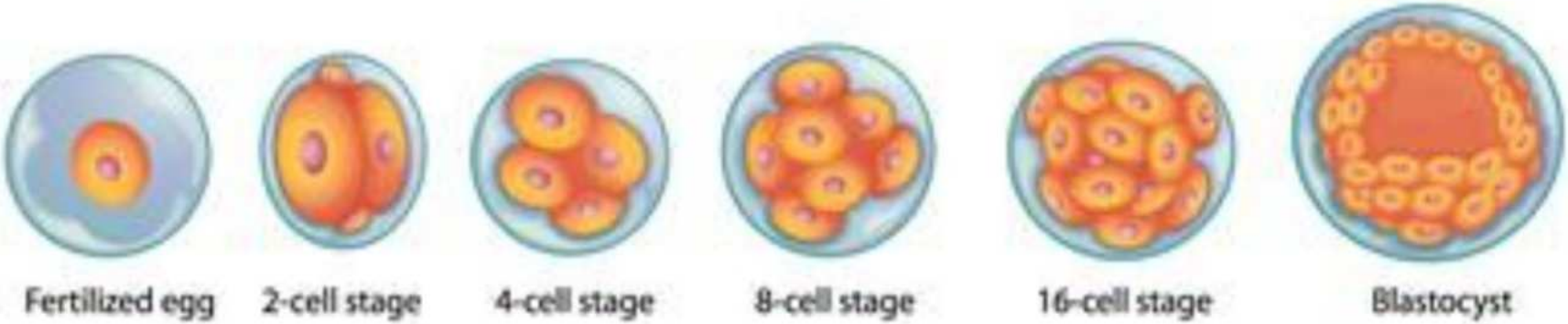
Human Embryonic and Foetal Development



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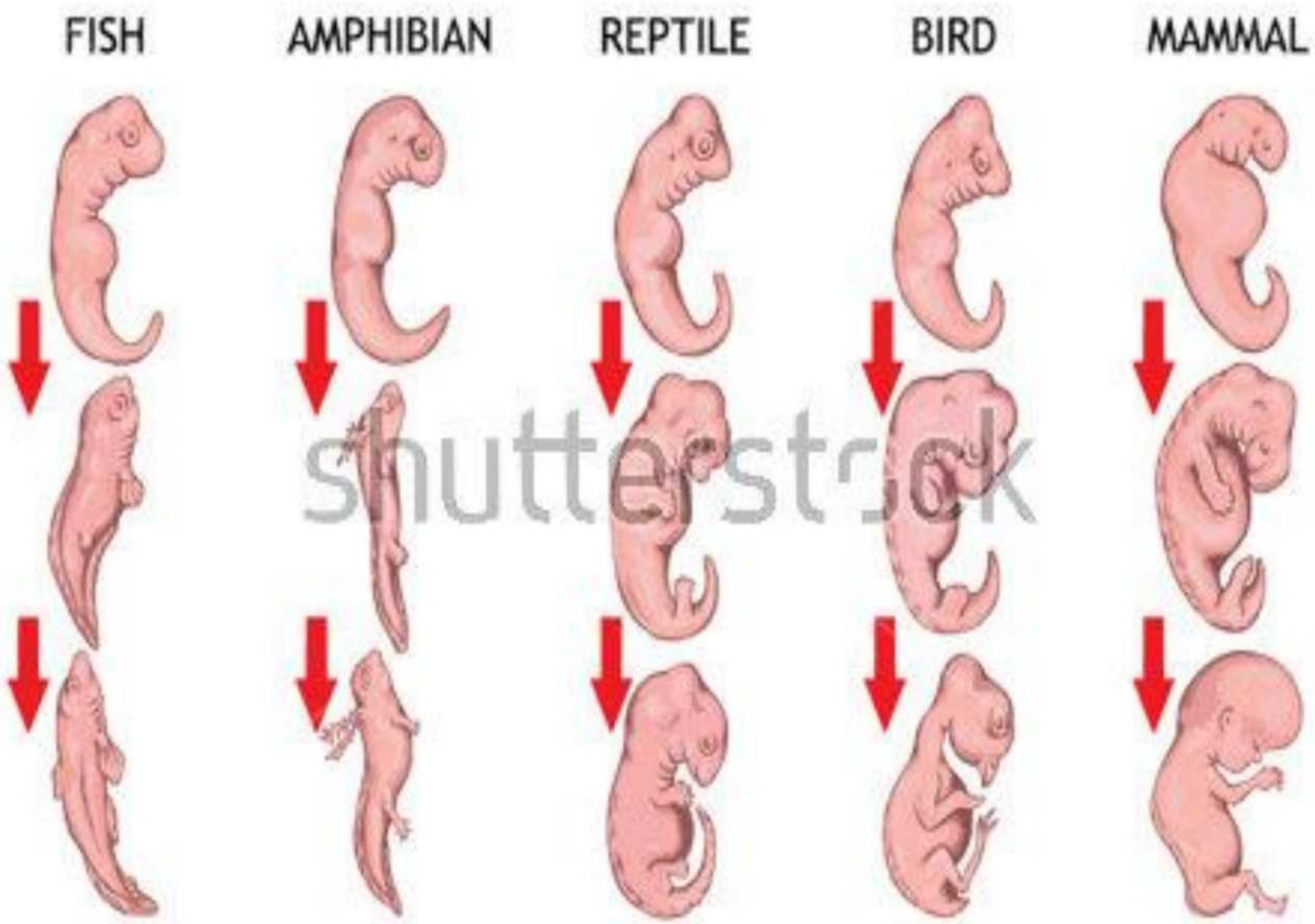

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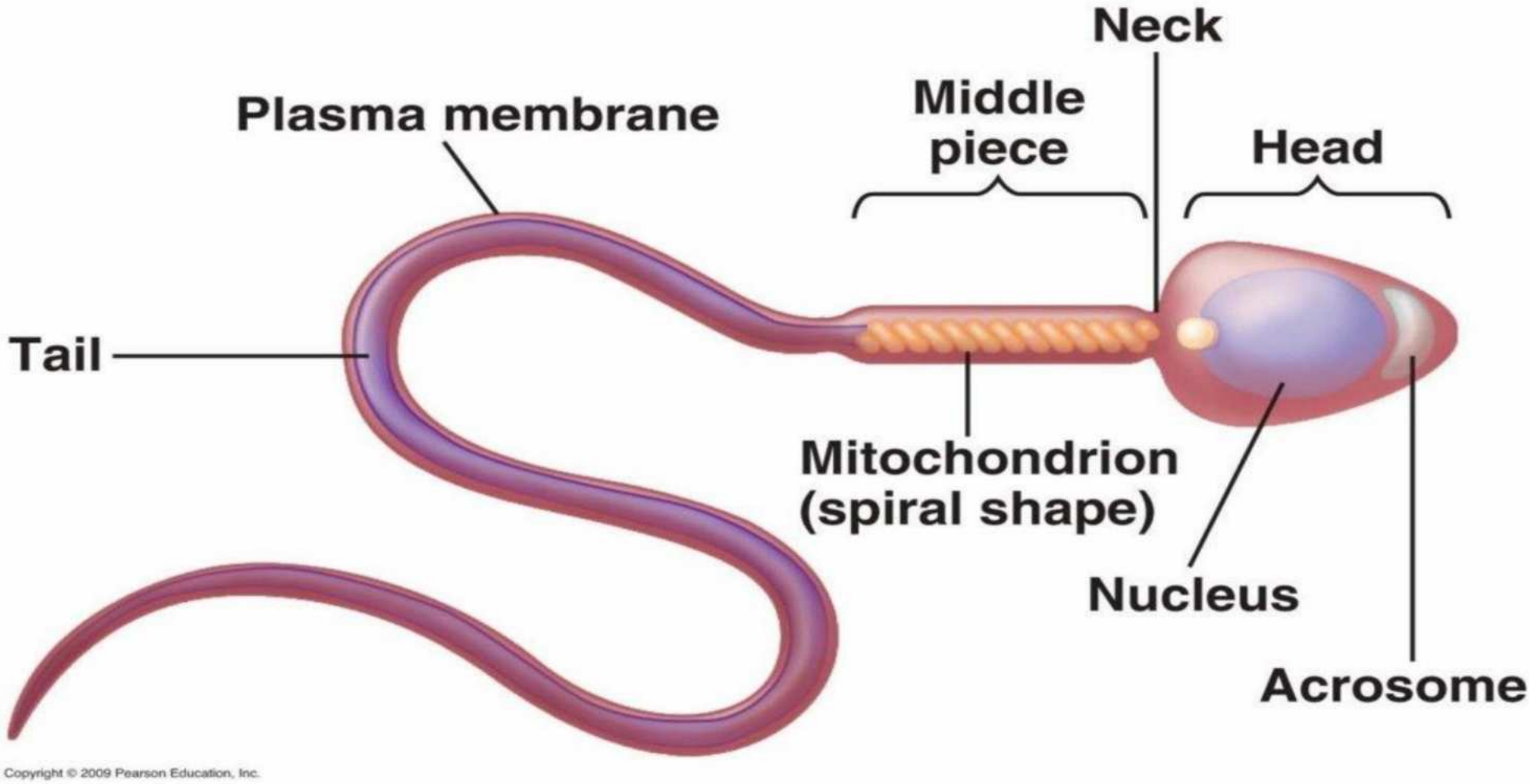
HUMAN SPERM



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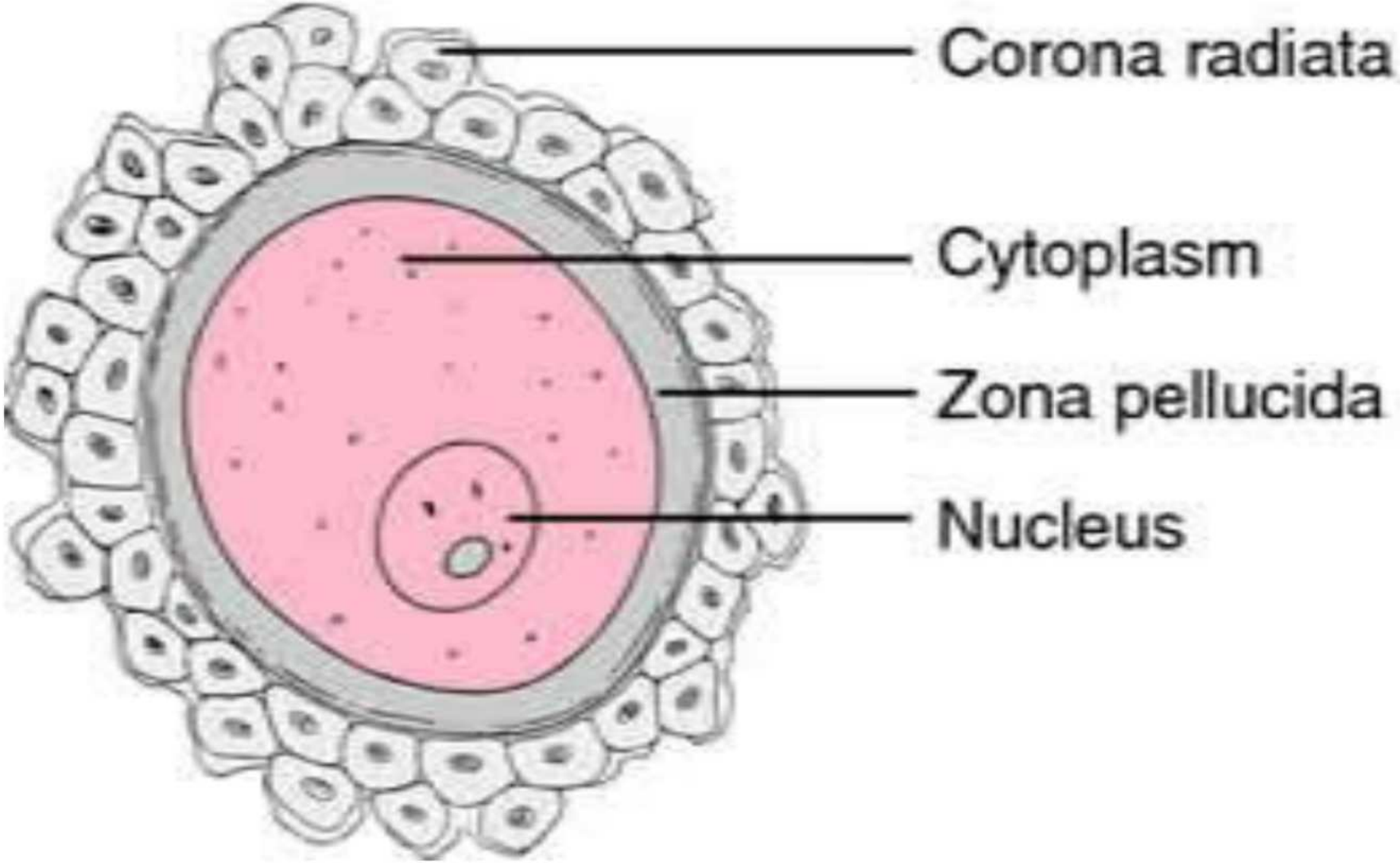
OVUM



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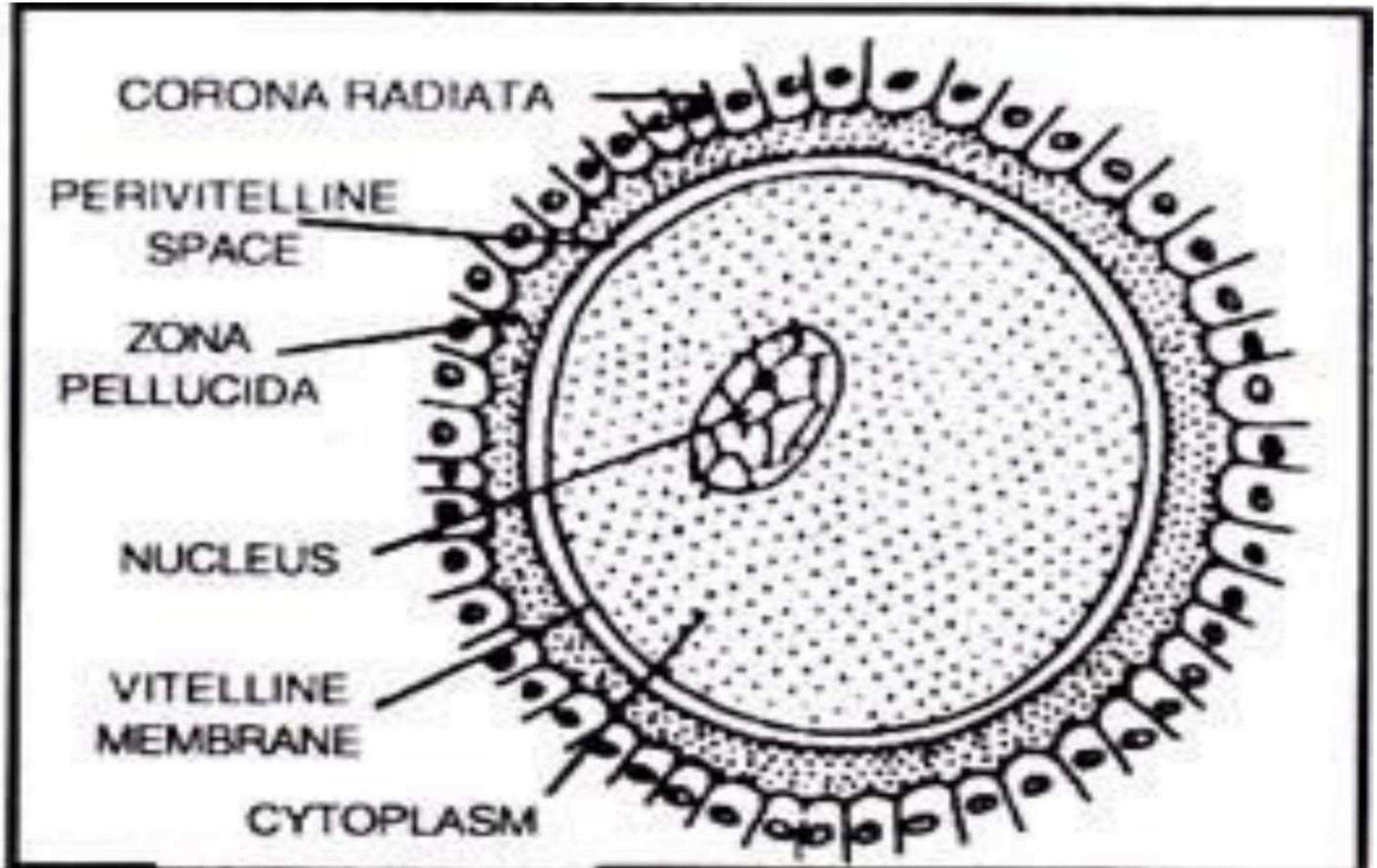

Fig. 3(B).7(A) Structure of an ovum.

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The ova are developed from the primitive germ cells which are imbedded in the substance of the ovaries. Each primitive germ cell gives rise, by repeated divisions, to a number of smaller cells termed **oogonia,** from which the **ova** or **primary oocytes** are developed.

1 Human ova are extremely minute, measuring about 0.2 mm. in diameter.

2 In appearance and structure the ovum (Fig. 3) differs little from an ordinary cell, but distinctive names have been applied to its several parts; thus, the cell substance is known as the **yolk** or **oöplasm,** the nucleus as the **germinal vesicle,** and the nucleolus as the **germinal spot.**

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The ovum is enclosed within a thick, transparent envelope, the **zona pellucida,** adhering to the outer surface of which are several layers of cells, derived from those of the follicle and collectively constituting the **corona radiata.**

Yolk.—The yolk comprises (1) the **cytoplasm** of the ordinary animal cell with its spongioplasm and hyaloplasm; this is frequently termed the **formative yolk;** (2) the **nutritive yolk** or **deutoplasm,** which consists of numerous rounded granules of fatty and albuminoid substances imbedded in the cytoplasm.

Germinal Vesicle.—The germinal vesicle or nucleus is a large spherical body which at first occupies a nearly central position, but becomes eccentric as the growth of the ovum proceeds.

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Developmental Process

Egg cells are produced well before birth in a huge number of so called primordial egg cells (primordial oocytes). From the beginning on, there is a continuous process of dying, so that at birth 2 million are left. That process of dying goes on after birth there remain about 40,000 ova. Then every four weeks a onset of puberty number of them begin a process of maturation Of these, only one (sometimes two or three) ovum matures, the rest dies. In total about 400 ova mature (13 per year for 30 years). At menopause, no primordial egg cells are left.

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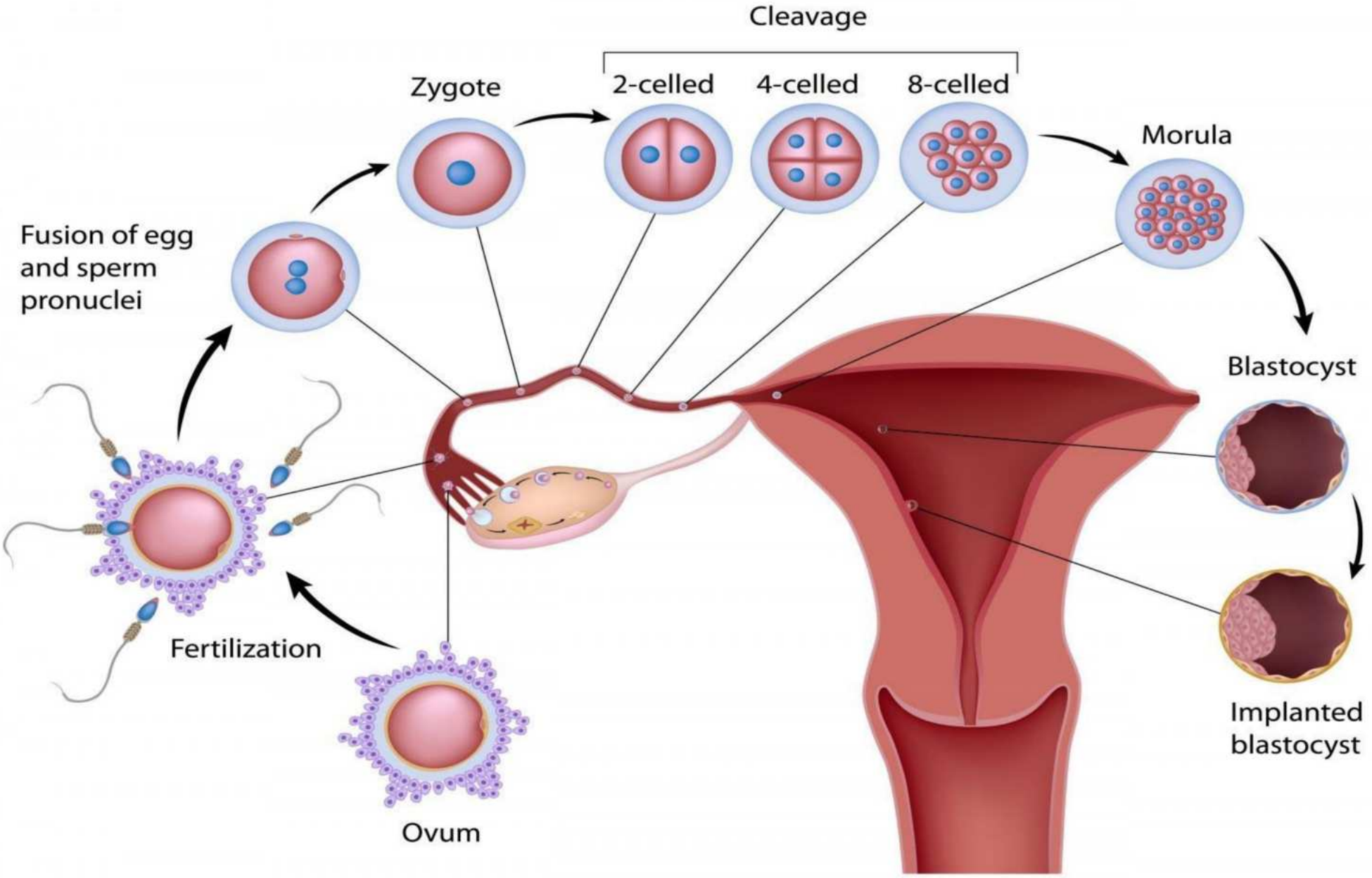
FERTILIZATION



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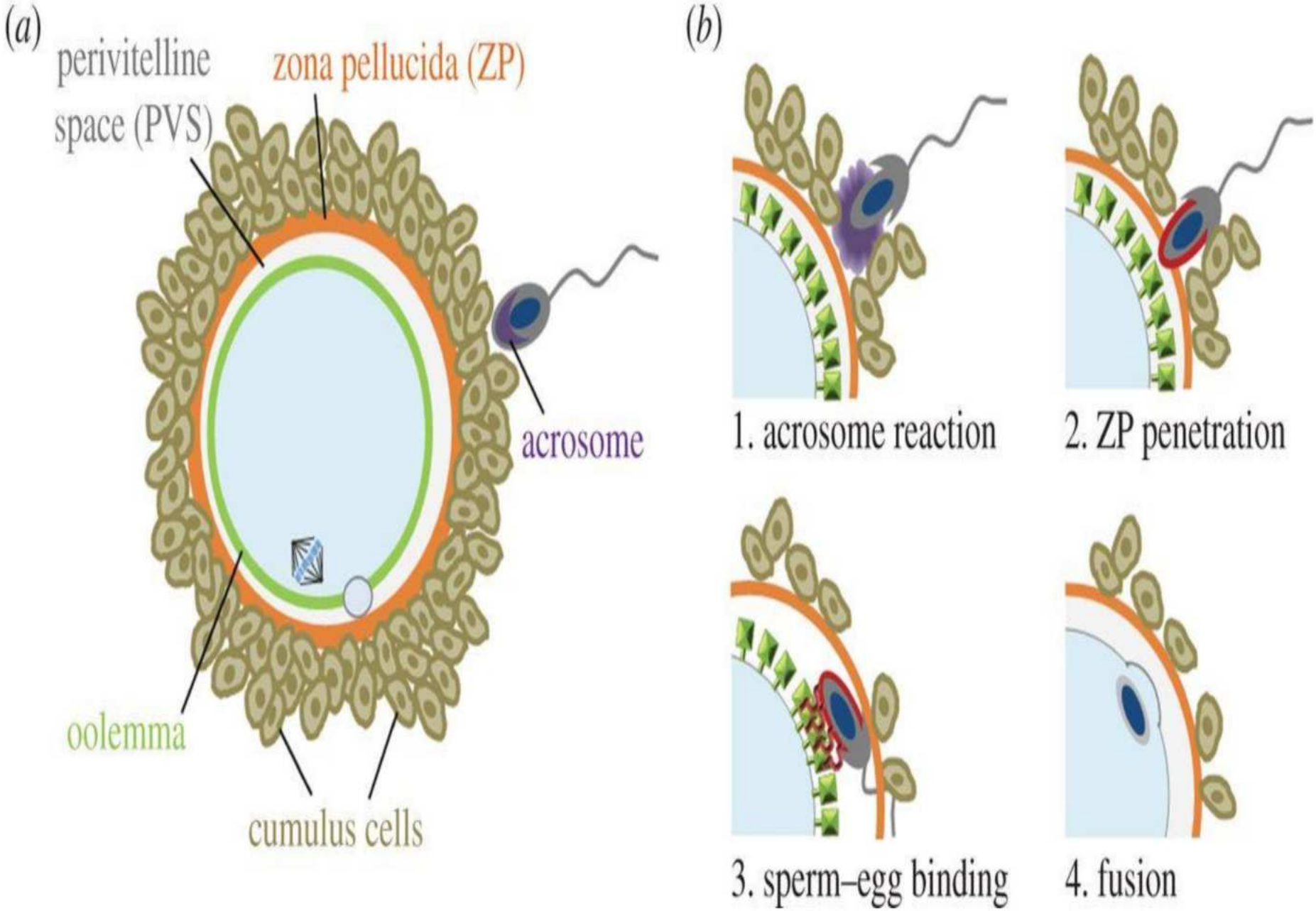

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- Definition- Process of fusion of two highly specialized mature ,haploid germ cells, An ovum and a spermatozoa resulting in the formation of a most unspecilized or diploid mononucleated single cells Zygote.
- Fertilization is a signal for completion of second meiotic division.Out of a few hundred capacitated sperms,that surround the ovum ,only one pierces the zona pellucida and enters the ovum . As soon as one spermatozoa enter the ovum , the second meiotic division is completed .

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Fertilization is fusion of male and female pronuclei- As the nucleus of the ovum become the female pronucleus.The head of the spermatozoa separates from the middle piece and tail and transformation itself into the male pronucleus.

Soon thereafter , the pronuclei lose their nuclear membranes . The 23 chromosome of the female pronucleus and the 23 of the male pronucleus get mixed up and form 23 pair (46 chromosome).Hence fertilization is the fusion of male and female pronuclei /chromosome.

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fertilization initiates mitotic division of zygote resulting in the formation of a multicelluer organisum .

Site of fertilization- Fertilization of the ovum occurs in the ampulla or lateral one- third of uterine tube.

Stages of fertilization- the various events in fertilization can be described in three stages.

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1.Appoximation of gametes.

2.Contact and fusion of gametes.

3.Effects of fertilization.

- Maturity and motility of sperm-

During their passage through male genital tract the spermatozoa mature. Movement of tail are important for their motility. Motility is important for penetration of three barriers surrounding the ovum.

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Transport of sperm- The prostaglandins present in semen stimulate peristaltic contraction of female genital tract at the time of sexual intercourse. During their transport there will be reduction in the number of spermatozoa due to the contraction in female genital tract. Movement of their tails through uterus and tubes assisted by muscular contraction are responsible for the movement of spermatozoa. Time taken for transport to uterus is 5-45 minutes.

Fate of spermatozoa - In female genital tract- Around 200-500 million sperms are deposite in the female genital tract and about 300-500 spermatozoa only reach the site of fertilization. The life span of spermatozoa after ejaculation in 24-48 hours.

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Capacitation- Capacitation is the final step in maturation of spermatozoa before actual fertilization and take place in female genital tract. The time required for capacitation is 7 hours. It start in the uterus and continues into the tube. The mechanism of capacitation is not known. It involves in the sperm cell membrane and signal transduction (Calcium influx, release of acrosomal enzyme etc). Certain major changes in surface glycoproteins (removal glycoproteins cut and exposing zona binding proteins) is caused by secretion of the female genital tract thus allowing sperm-egg binding. An immunological reaction between the fertilizin on ovum and anti-fertilizin on spermatozoa.

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Ovum transport- The stracture of ovum at ovulation, transport of ovum from ovary to ampulla of uterine tube and viability of sperm are important for the success of fertilization.

Structure of ovum at ovulation- At ovulation the ovum contains secondary oocyte with 23 unpaired chromosomes enclosed in vitelline membrane surrounded by zona pellucida with protein and corona radiata.

Transport of ovum from ovary to ampulla of uterine tube- The fimbriae of uterine tube moves over the ovary at ovulation and the cilliary beats of fimbriae sweeps the ovulatory mass into the infundibulum. The ciliary beats of uterine epithelium and muscular contraction of uterine tube are responsible for migration of ovum from the surface of ovary into the ampulla of uterine tube. The ovum reaches ampulla the site of fertilization in 25 minutes.

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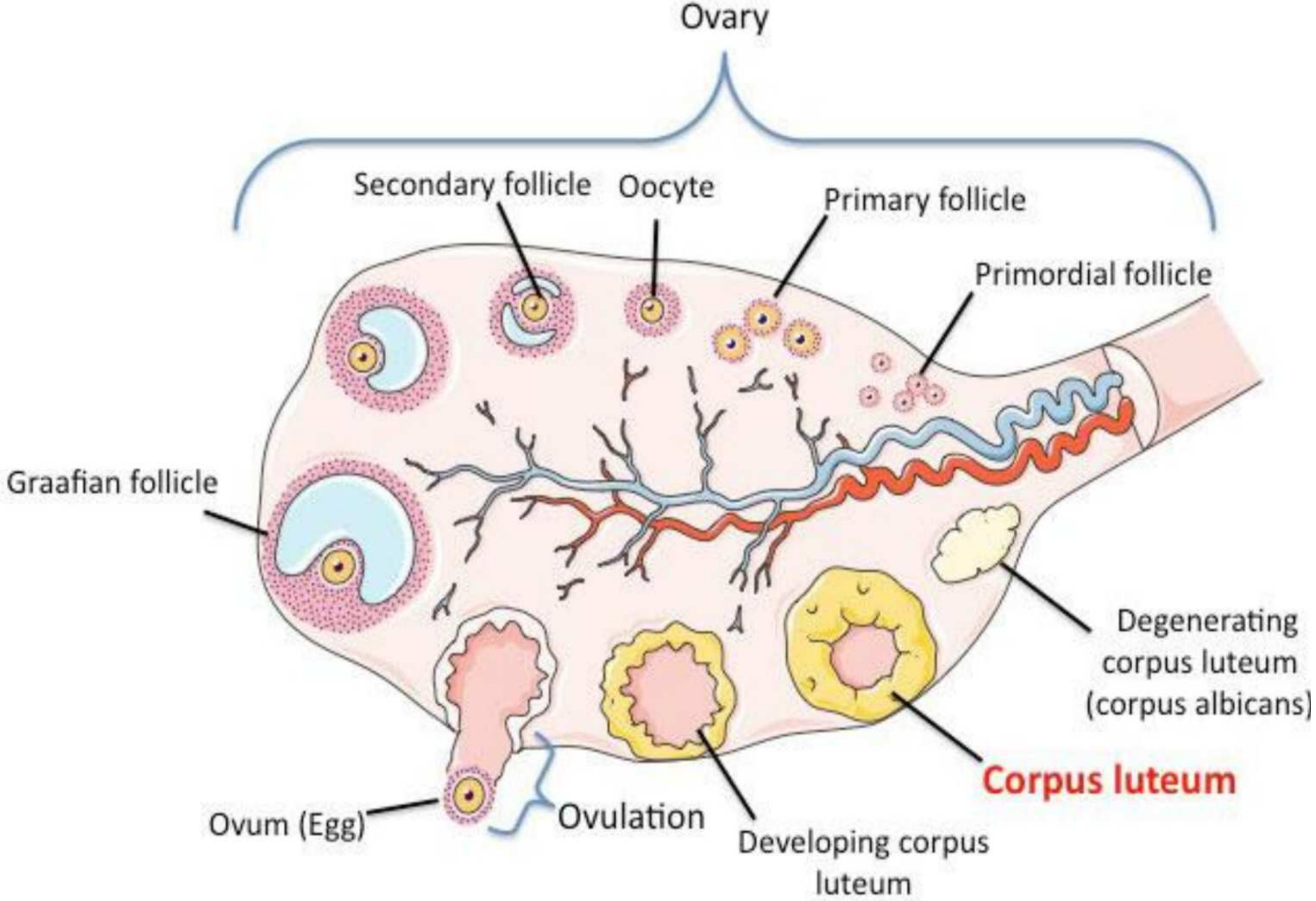

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Vability of ovum- The ovum that is released at ovulation is viable for 24-48 hours.

CLEAVAGE

Definition- The cleavage division start immediately after fertilization and continue as the zygote is passing through the uterine tube toward uterus. The cleaving zygote is covered by zona pellucida.This journey is facilitated by ciliary movements of uterine epithelium and contraction of uterine tube masculature.

Duration-The cleavage division up to 7 days after fertilization.

Stages of cleaving egg- During it's journey through uterine tube , the cleaving egg passes through the following stages.

At the first cleavage division the zygote forms one large and one small cell. In the next cleavage the larger cell divides first followed by smaller one.

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Subdivision of cleavage- There are three division of cleavage :

They are

1. Stage of compaction- It start at third division,at 8-cell stage. There will be maximal contact between the cell. Outer cell form tight junction & inner cell form gap junction.
2. Morula-As cleavage proceeds the fertilized ovum comes to have 16 cells. It now looks like mulberry and is called the morula. It is still surrounded by the zona pellucida. Cells are similar in size and structure. If we cut a section across the morula, we see that it consist of inner cell mass that is completely surrounded by outer layer of cells.

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- The cell outer layer will later give rise to a structure called the trophoblast that form the covering of the embryo. The inner cell mass gives rise to embryo proper and is also called embryoblast. The cell of the trophoblast help to provide nutrition to the embryo.

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BLASTOCYST :-

Between 4^{th} and 5^{th} day or 32 cells stage some fluid passes into the morula from the uterine cavity,and partially separates the cell of inner cell mass from those of the trophoblast. As the quantity of fluid increase, the morula acquire the shape of cyst. The cell of the trophoblast become flattened and the inner cell mass gets attached to the inner side of the trophoblast on one side only. The morula has now become a blastocyst. The cavity of the blastocyst is called blastocele.

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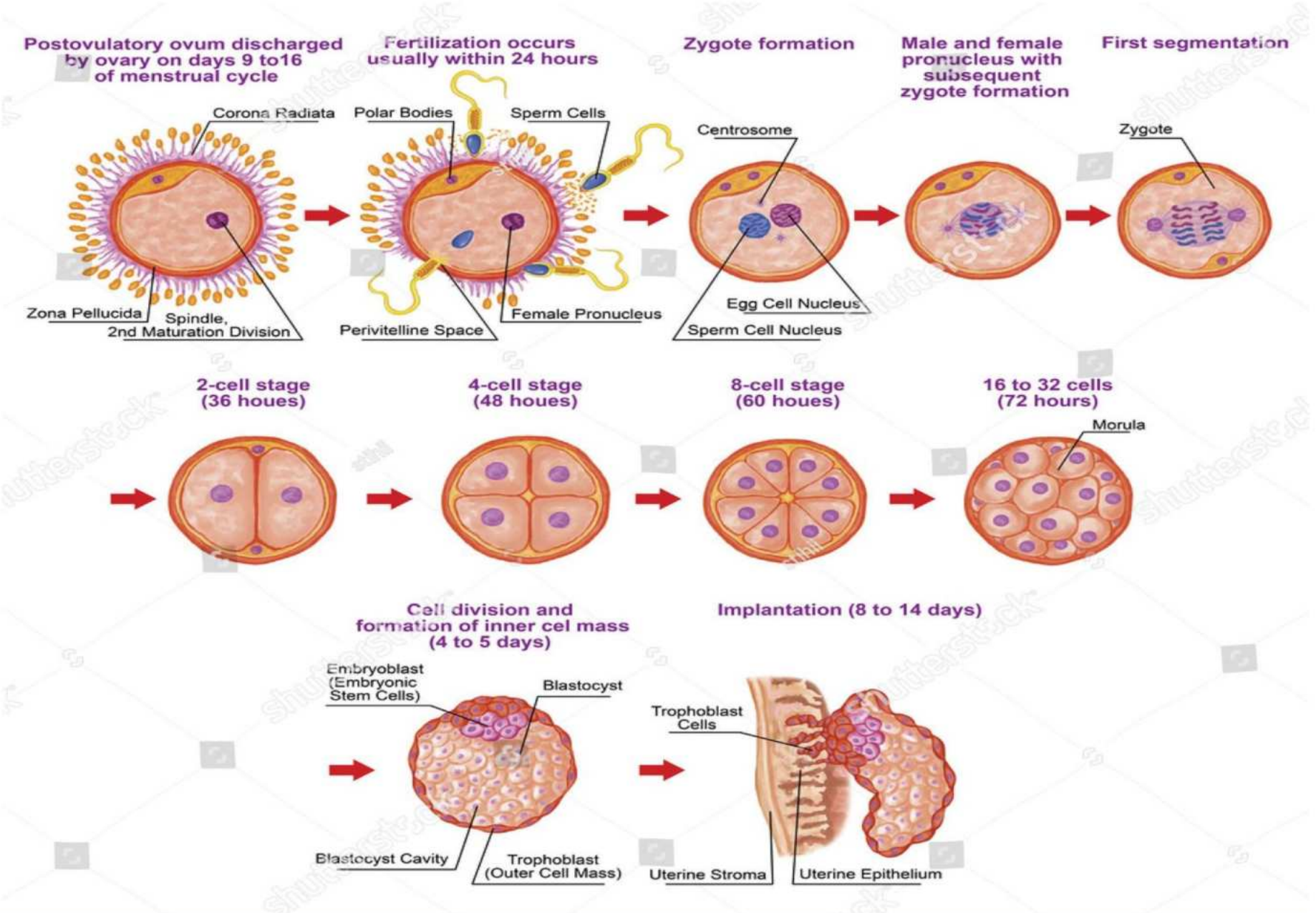

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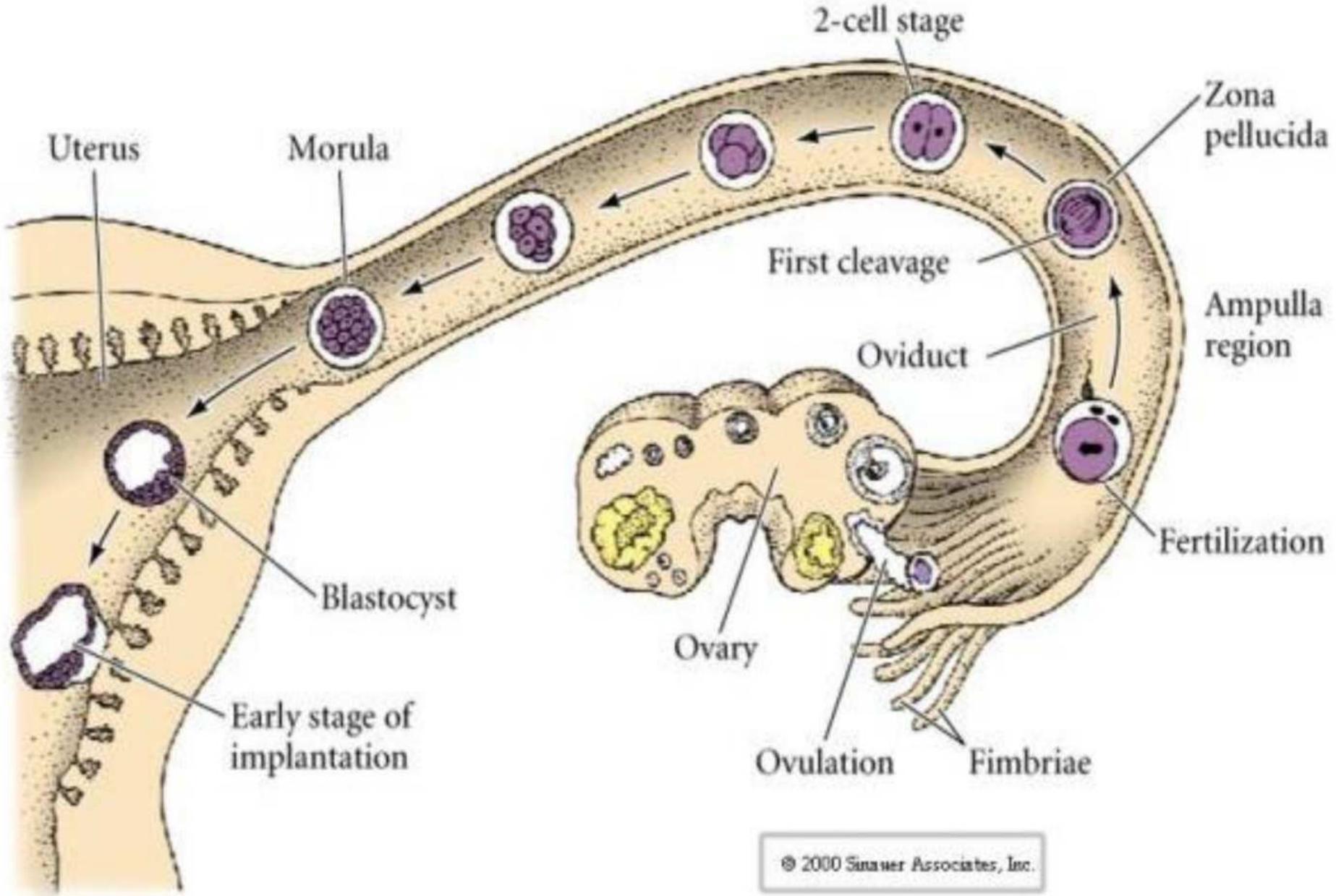

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Cleavage stages	Time after fertilization when it can be observed
One cell stage	<24 hrs
Two cell stage	24-36 hrs
3-4 cell stage	36-48 hrs
5- 8 cell stage	48-72 hrs
9-16 cell stage	72-96 hrs

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Cleavage and blastocyst formation

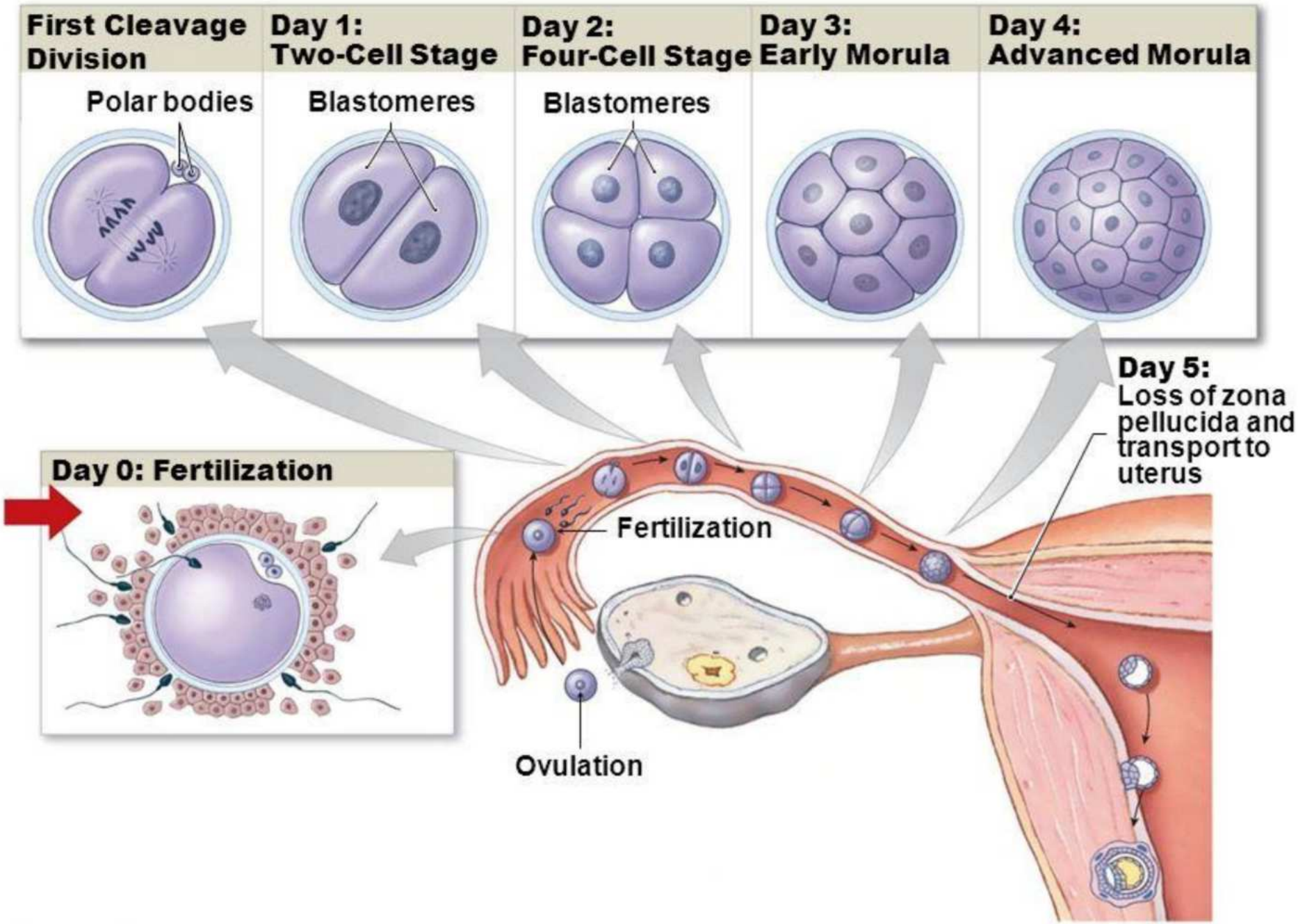

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Figure 19.1

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IMPALANTATION

Definition- It is the process of attachment of blastocyst to uterine endometrium and subsequent invasion of blastocyst into the uterine endometrium in placental animals.

Period- It take place between 6^{th} and 12^{th} day after fertilization.

Process of implantation

1.Preliminary implantation

Ovulation

Fertilization

Cleavage

Morula

Blastocyst

Inner cell mass

Outer cell mass

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PROCESS OF IMPLANTATION

Decidual reaction/ changes in uterine endometrium- When the morula reaches the uterus the endometrium in the secretory phase of mentruation cycle. The changes in the endometrial stroma with implantation of blastocyst is called the decidual reaction.

Hatching of blastocyst- The zona pellucida of the cleaving blastocyst that is disappear on the uterine wall gradually become thin on 5^{th} day. This thinning is due to the production of trypsin like enzyme that cause dissolution of zona pellucida. By 6^{th} day the zona pellucida disappears.

Adhesion to uterine endometrium- The trophoblast has the tendency to stick to the structure with which it come in contact. Once the zona pellucida disappears the cell of the trophopbalst stick to the uterine endometrium. This is called the beginning of the process of implantation.

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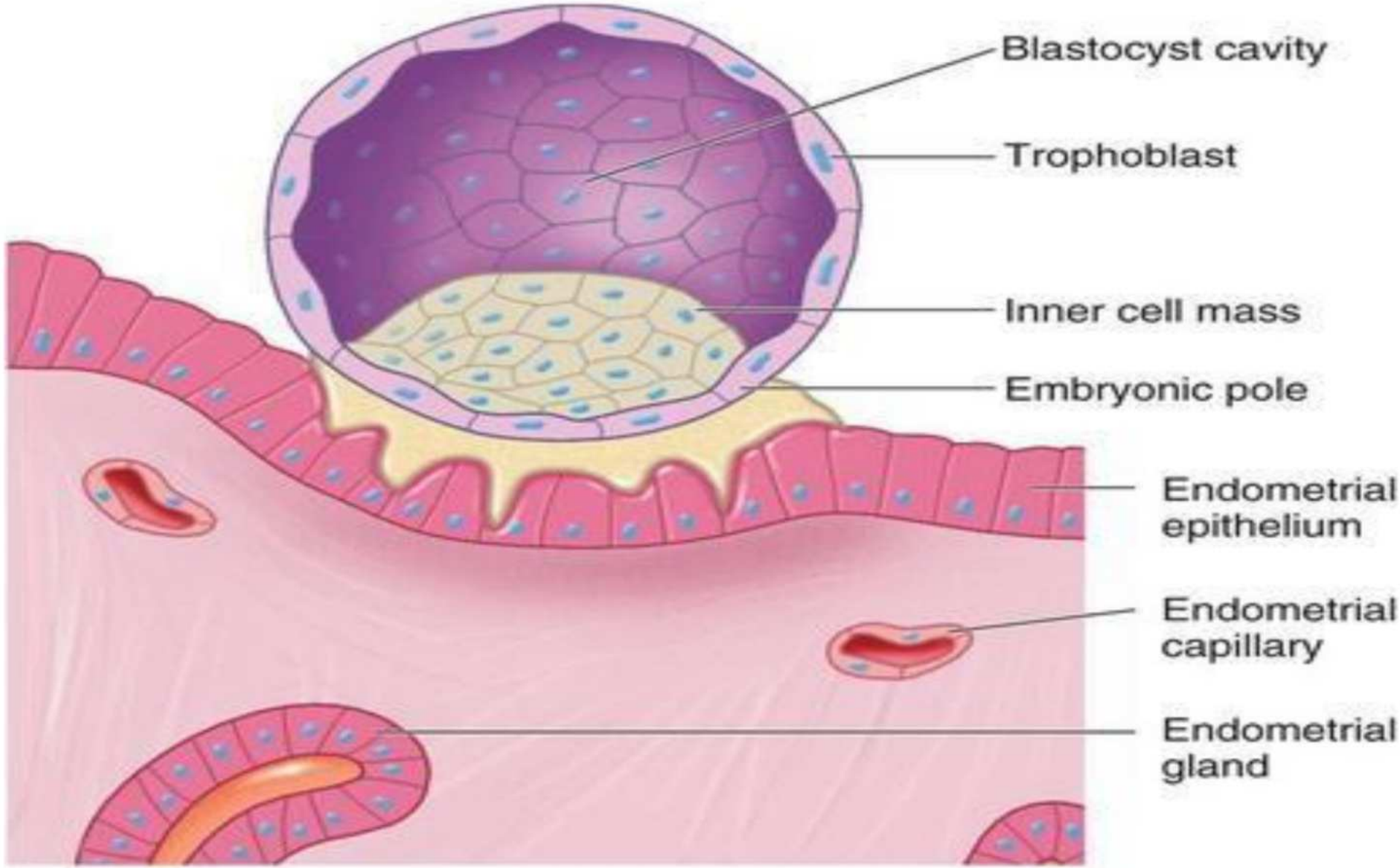

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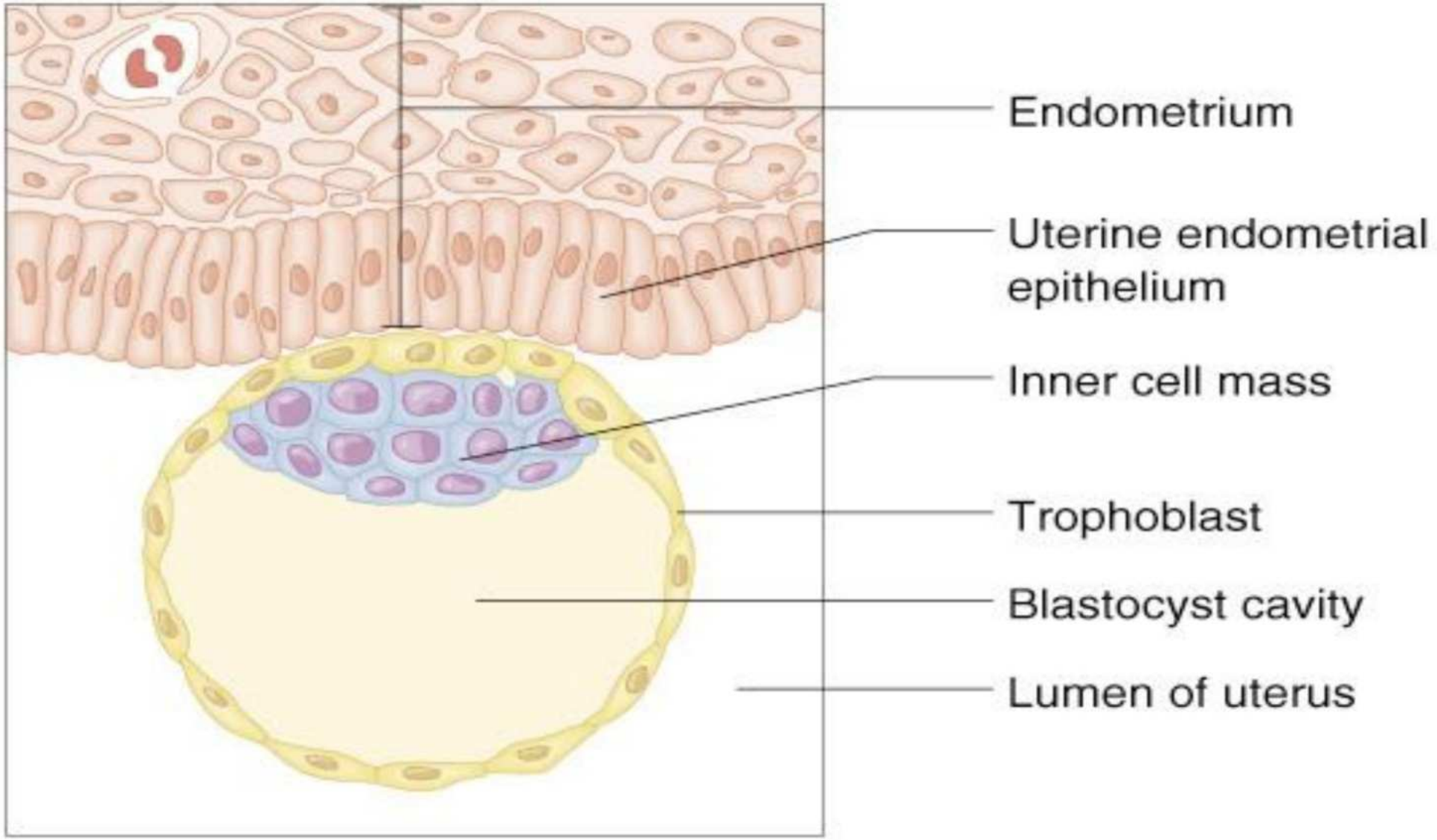

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Penetration of blastocyst through uterine epithelium- The trophobastic cells have got the penetrating in nature. The trophobalst cells situated over the embryoblast /inner cell mass & start penetration of the uterine epithelium to provide passage for the blastocyst.

Erosion of uterine endometrium- Erosion of stratum compactum and stratum spongiosum by the cell of polar trophoblast occurs. This is due to the proteolytic enzyme secreted by both polar trophoblast and uterine endometrium. The blastocyst burrows deeper and deeper into the uterine mucosa till the whole of it comes to lie within the thickness of endometrium.

Differentiation of trophoblast- By about 8^{th} day of development, the blastocyst partially embedded into the uterine emdometrial stroma.

The trophoblast differentiates into the two layer-

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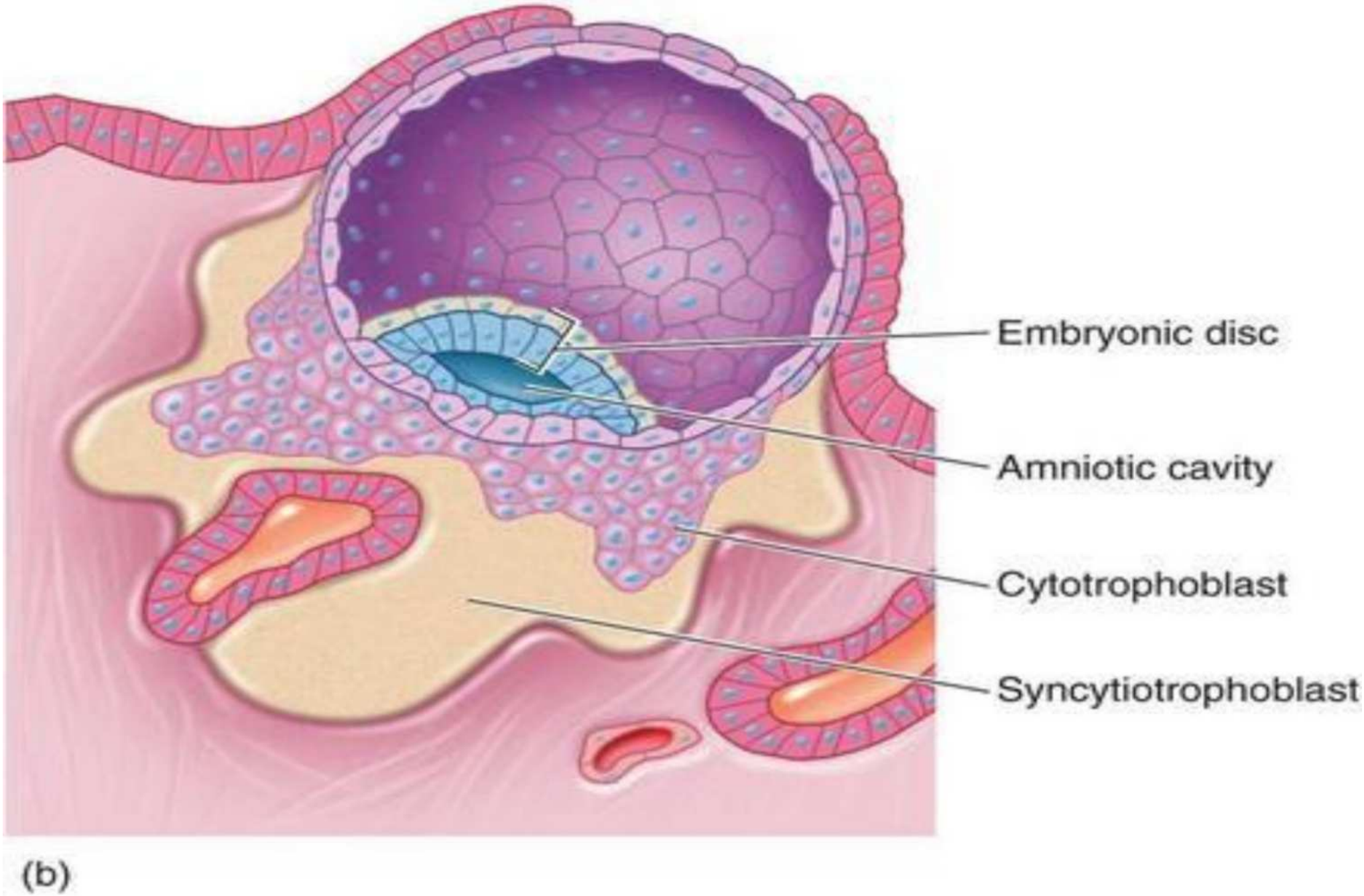

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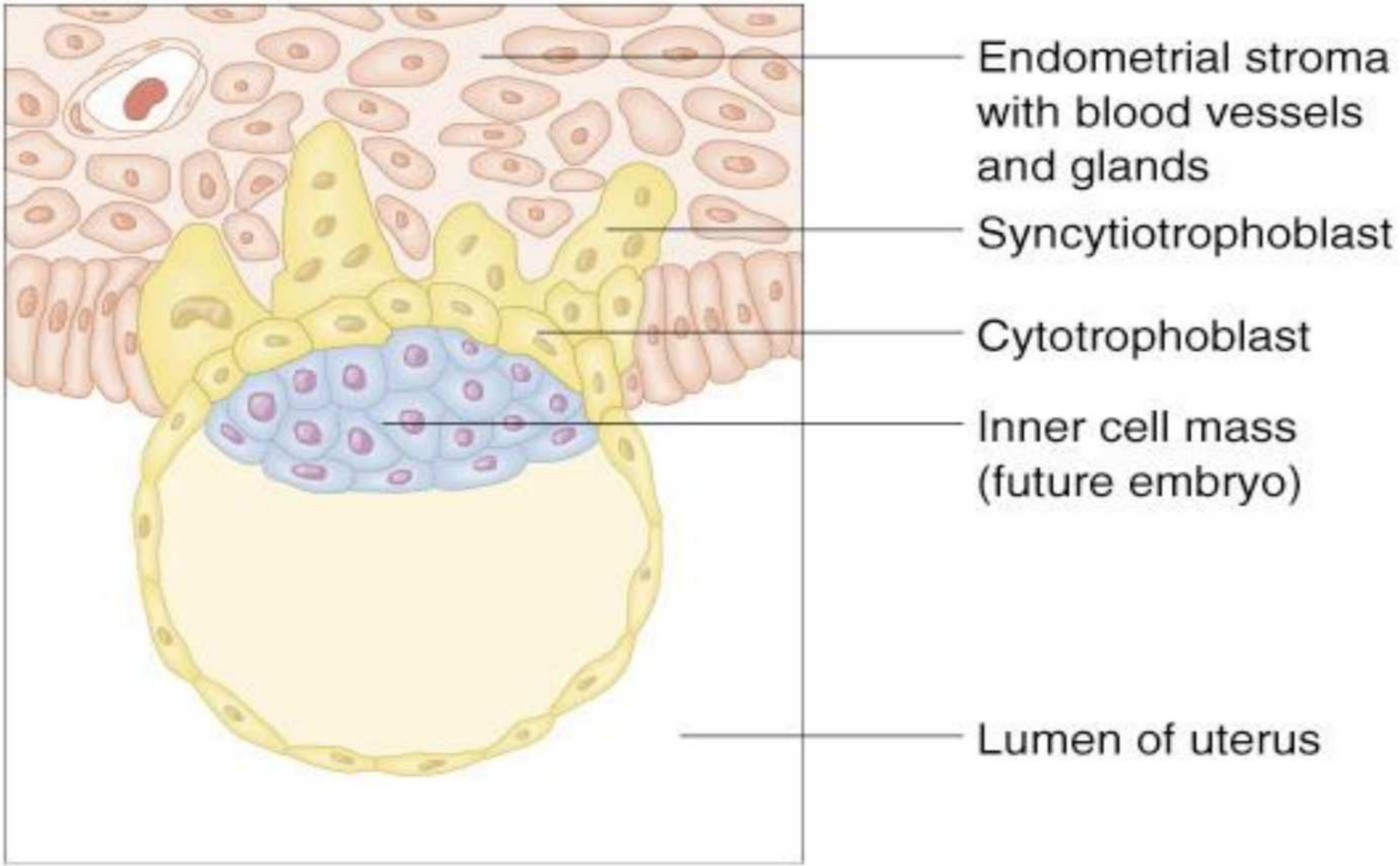

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Cytotrophoblast-The inner layer of cells is cuboidal to low columnar mononucleated.

Syncytial trophoblast-The outer layer of multinucleated cells.These are formed by the dividing cells of cytotrophoblast that have migrated to the periphery and fused.

Closure of penetration defect in uterine epithelium- Once passage of blastocyst through epithelial surface is completed closure of penetration defect in surface epithelium take place around 9^{th} day after fertilization by a coagulum of tissue fluid and debries that forms a fibrin plug.

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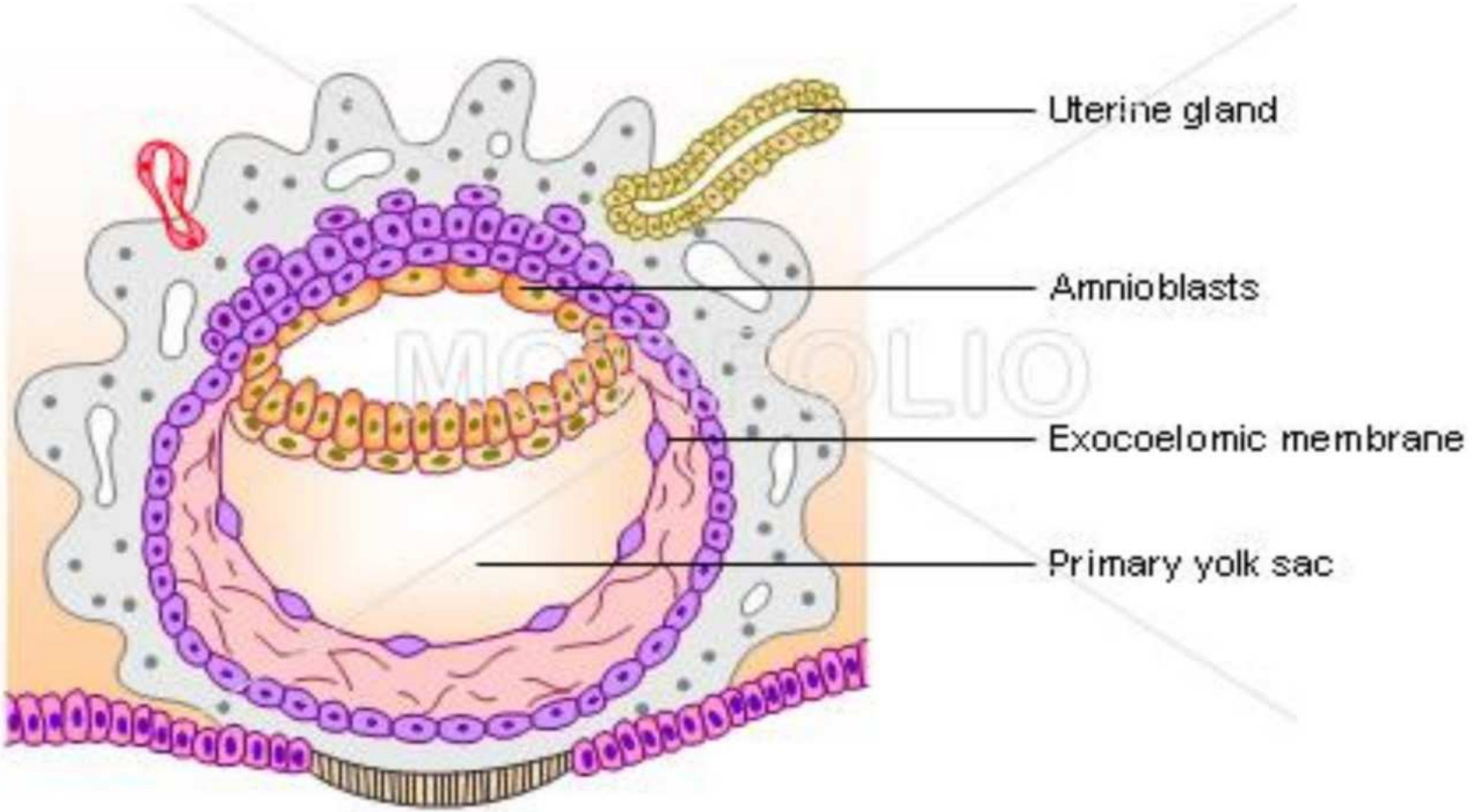
Implantation of blastocyst – 9 days, syncytiotrophoblast invades the uterine



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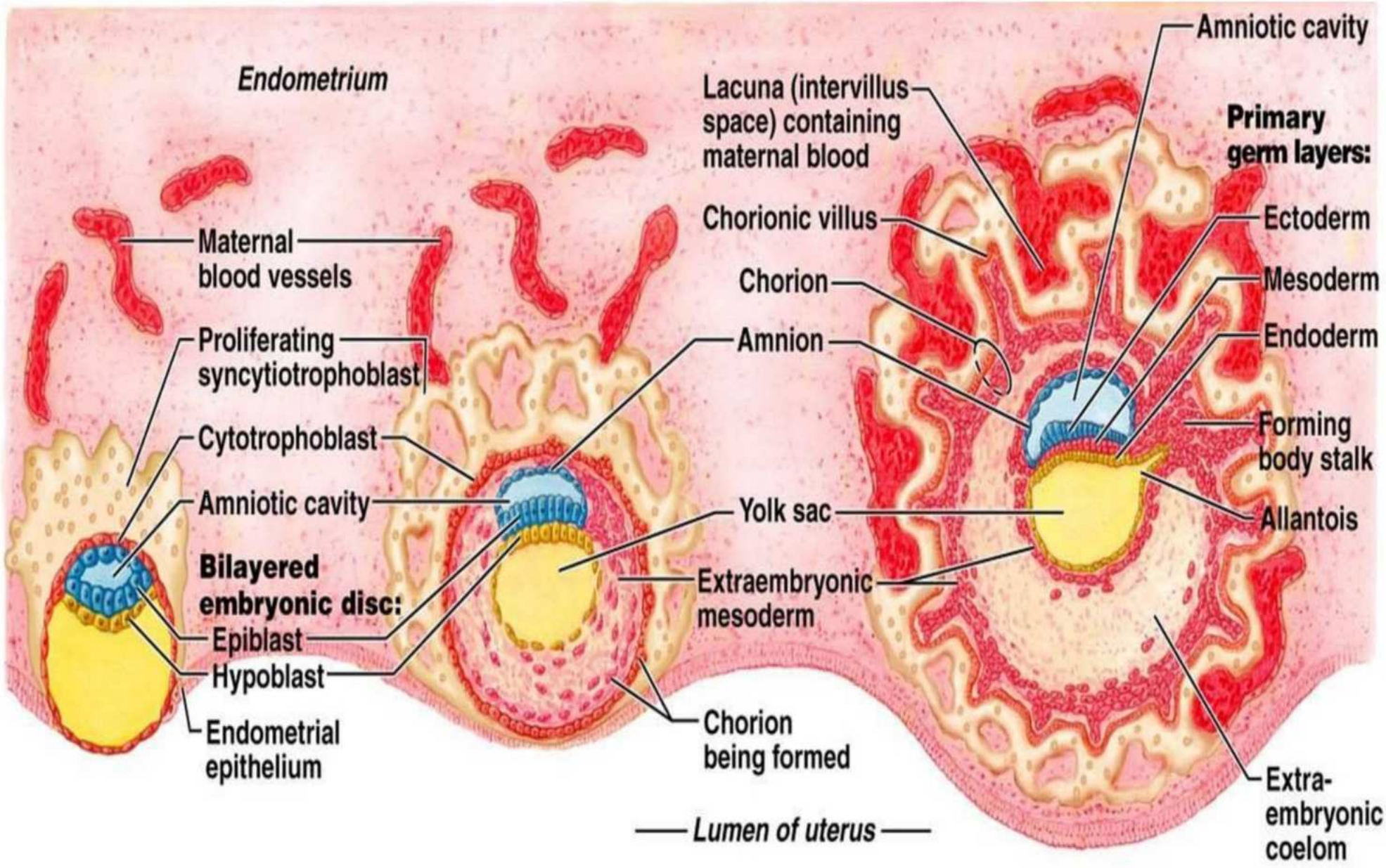

(a) 7½-day implanting blastocyst

(b) 12-day implanted blastocyst

(c) 16-day embryo

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Completion of embedding of blastocyst and establishment of nutritive relationship with maternal blood vessels- By 12th day of fertilization , The blastocyst has completely embedded in the endometrium.

Type of implantation-

1. **Central implantation-** Blastocyst is implanted in the uterine cavity like a cow.
2. **Eccentric implantation**- Blastocyst is implanted in the uterine cavity like a mouse.
3. **Interstitial implantation-** Blastocyast implant in the endometrium of uterine wall. Like a human.

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MONTH WISE FETAL DEVELOPMENT

1st month- Conseption, fertilization and implantation ,after ovulation,the egg is normally fertilized the within 24-48 hours. The single fertilized cell begin to rapidly divide and at this point. This single cell is called zygote. Between 1 to 7 days from fertilization implantation usually occurs. **The amniotic sac, umbillical cord and yolk sac are beginning to form. By the end of this month embryo is approximately 2mm long.**

2nd month- Heart, neural tube, arm and legs, liver and other major organs begin to form. By 6th week the heart start beating and visible ultrasound.The eyes,ear,mouth and bones are under formation.In this month baby's finger and toes are present. Fetus is approximately 2 inch long and weight about 1-2 grams.

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3rd month- Development of the heart and all major organ is complete by the end of the third month.Sex organs continue to develop. Muscles in trunk,limbs and head are developing. Baby is 3-4 inches long and weight about 30 gm.

4th month- Baby's hair and teeth begin to **form.**

Mother feels baby's movement in this month.Baby's digestive system is forming and the intestine are present.Meconium, baby's first stool is present in the intestines. Fetus is approximately 5-6 inches long and weight 140-240 gm by the end of this month.

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5th month- Fine hair are developed is called lanugo, which covers the bady. Vernix a white cheese like covering,appears on fetus to protect her skin. Fetus is approximately 7-8inch long and weight 340-440 gm by the end of this month.

6th month- Lungs are beginning to developed and alveoli are forming. Immune system is developing and beginning to create own antibodies. By the end of this month length is approximately 9-10 inches long and weight in at about 680-1000 gm.

7th month- Bone are fully developed with increase in fat amount now. By the this month, it is approximately 11inches long and weigth around 1360-1500 gm

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8th month- Fetus is approximately 13 inches long and weight around 2200-2500 grams at the end of the this month.

9th month- At birth normally weight ranges from 2.5-3kg and 19-21 inches in length.

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FORMATION OF GERMINAL LAYER

At a very early stage in development,the embryo proper acquires the form of a three layered disc. This is called embryonic disc.

The three layers that constitute this embryonic disc are following:

1. Endoderm
2. Ectoderm
3. Mesoderm

These are the three germ layer. All tissues of the body are derived from one or more of these layers.

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We have seen that the blastocyst is a spherical cyst lined by flattened trophoblastic cells and that inside it there is a mass of cells, the inner cell mass attached eccentrically to the trophoblast .Further changes are as follows:

1 **Formation of hypoblast- S**ome cells of the innner cell mass differentiates into flattened cells ,that come to line its free surface. This layer is the endoderm.

2.Formation of epiblast- The remaining cells of inner cell mass become colmner.These cells from the epiblast.The embryo is now in the form of a disc having two layers.

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3. **Formation of amniotic cavity-** A space appears between the epiblast below and the trophoblast above. This is a amniotic cavity fillled by amniotic fluid or liquor amnii. The roof of this cavity is formed by amniogenic cells derived from the trophoblast ,while its floor is formed by the epiblast.

4. **Formation of primary yolk sac- F**lattened cells arising from the hypoblast spread and lines the inside of the blastocystic cavity . In this way a cavity lined on all sides by cells of endoderm origins is formed. This cavity is called primary yolk sac.

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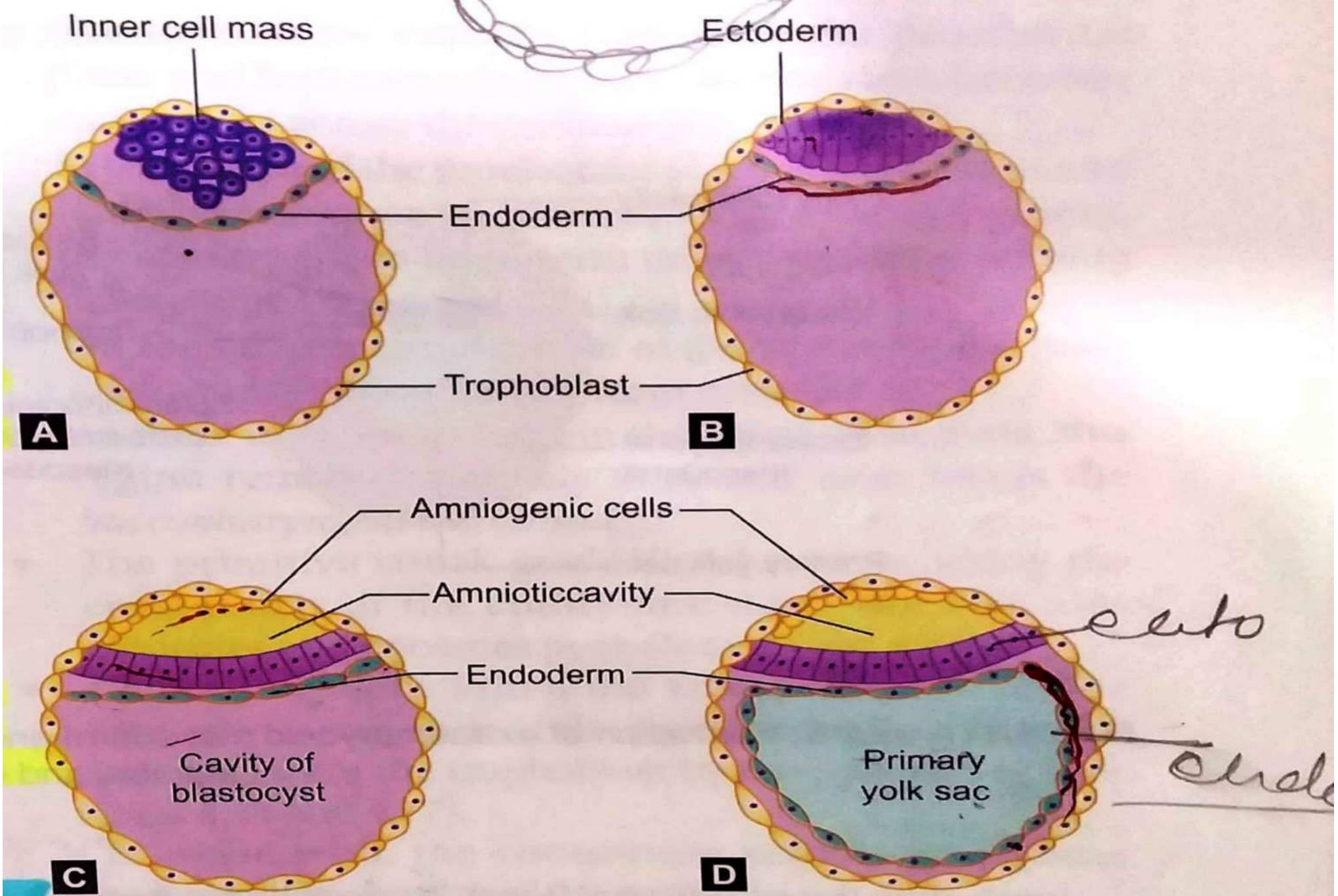

Figs 4.10A to D: Differentiation of endoderm and ectoderm, and the formation of the amniotic cavity and the yolk sac

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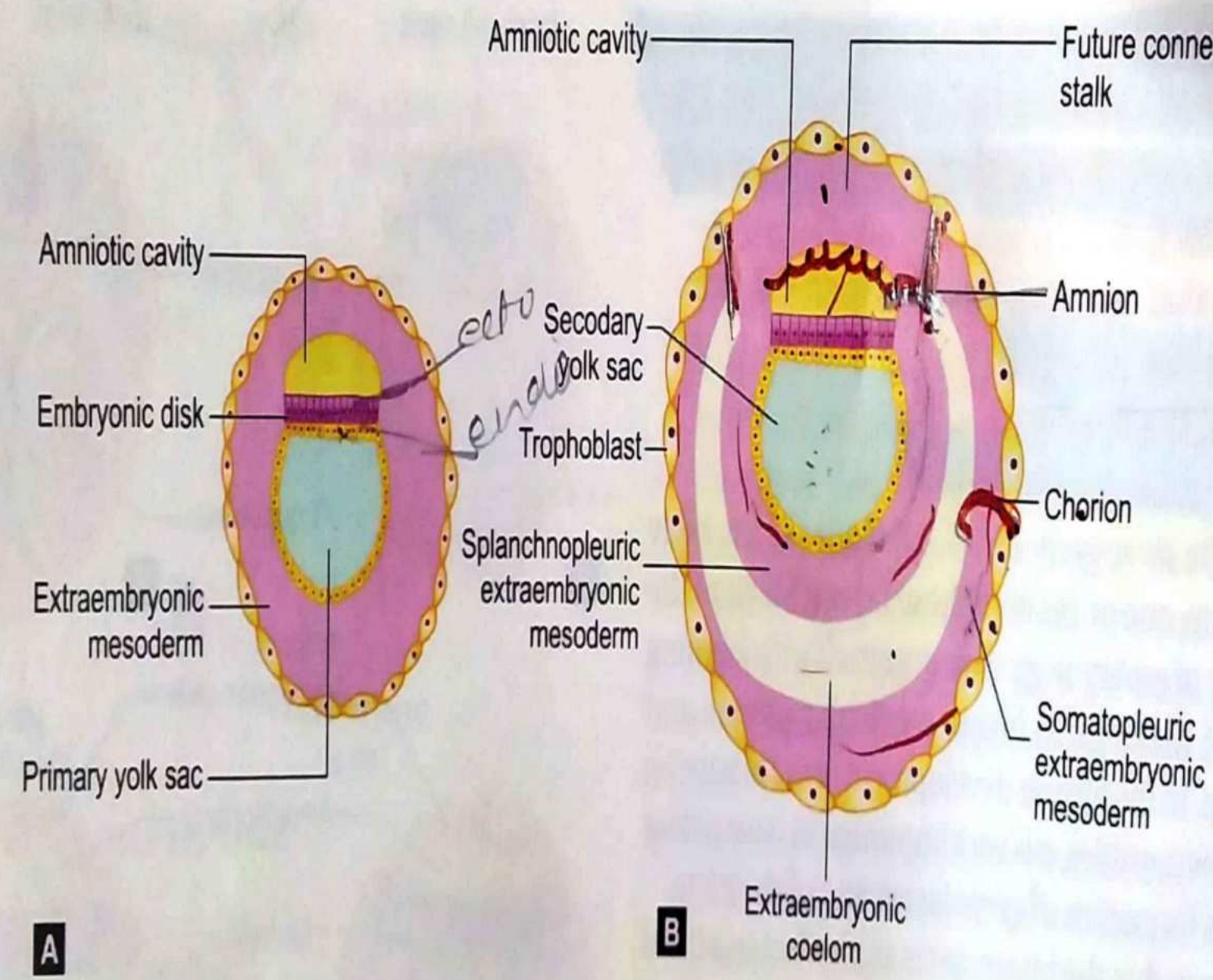

Figs 4.11A and B: Formation of extraembryonic mesoderm and extraembryonic coelom. Note carefully, the composition of the amnion, and of the chorion

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5.Formation of extrambryonic mesoderm- The cells of the trophoblast gives origin to a mass of cells called the extraembryonic mesoderm these cells come to lies between the trophoblast and the flattened endodermal cells lining the yolk sac thus separating them each other. This mesoderm is called extra embryonic because it lies outside the embryonic disc.

6.Formation of extraembryonic coelom-Small cavities appear in the extraembryonic mesoderm. Gradually these join together to form larger space and ultimately one large cavity is formed. This cavity is called the extraembryonic coelom.

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With its formation ,the extraembryonic mesoderm is split into two layer. The part lining the inside of the and the outside of the amniotic cavity is called the parietal 0r somatopleuric extraembryonic mesoderm.The part lining the outside of the yolk sac is called the visceral or splanchnopleuric extraembryonic mesoderm.

formation of connecting stalk- It is clearly seen that the extraembryonic coelom does not extend into that part of the extraembryonic mesoderm which attaches the wall of the amniotic cavity to the trophoblast.

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Formation of chorion and amnion- at this stage two very important membranes are formed. One is formed by the parietal extraembryonic mesoderm and the overlying trophoblast this is called the chorion.

The other is the amnion which is constituted by amniogenic cells forming the wall of the amniotic cavity. These cells are derived from the trophoblast.

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Formation of secondry yolk sac- with the appearance of the extraembryonic mesoderm and later of the extraembryonic coelom, the yolk sac become much smaller than before and is now called the secondary yolk sac.

circular embryonic disc- at this stage the embryo proper is a circular disc composed of two layer of cells.

1 the upper layer is the epiblast the cells of which are columnar.

2 the lower layer is the hypoblast.made up of cubical cells.

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SEX DETERMINATION

All ova contain 22+X chromosomes.however the spermatozoa are of two types. Half of them have 22+X chromosome and the other half of them have 22+Y chromosome. These are called as X bearing or Y bearing spermatozoa. If the sperm is X bearing the zygote has 44+xx chromosome and the offspring is a girl. If the sperm is Y-bearing the zygote has 44+X+Y chromosome and the offspring is a boy. Thus the sex of a child is determined at the time of fertilization depending on the contribution by the spermatozoa. It will now be clear that one chromosome of each of the 23 pair is derived from the mother and the other from the father.

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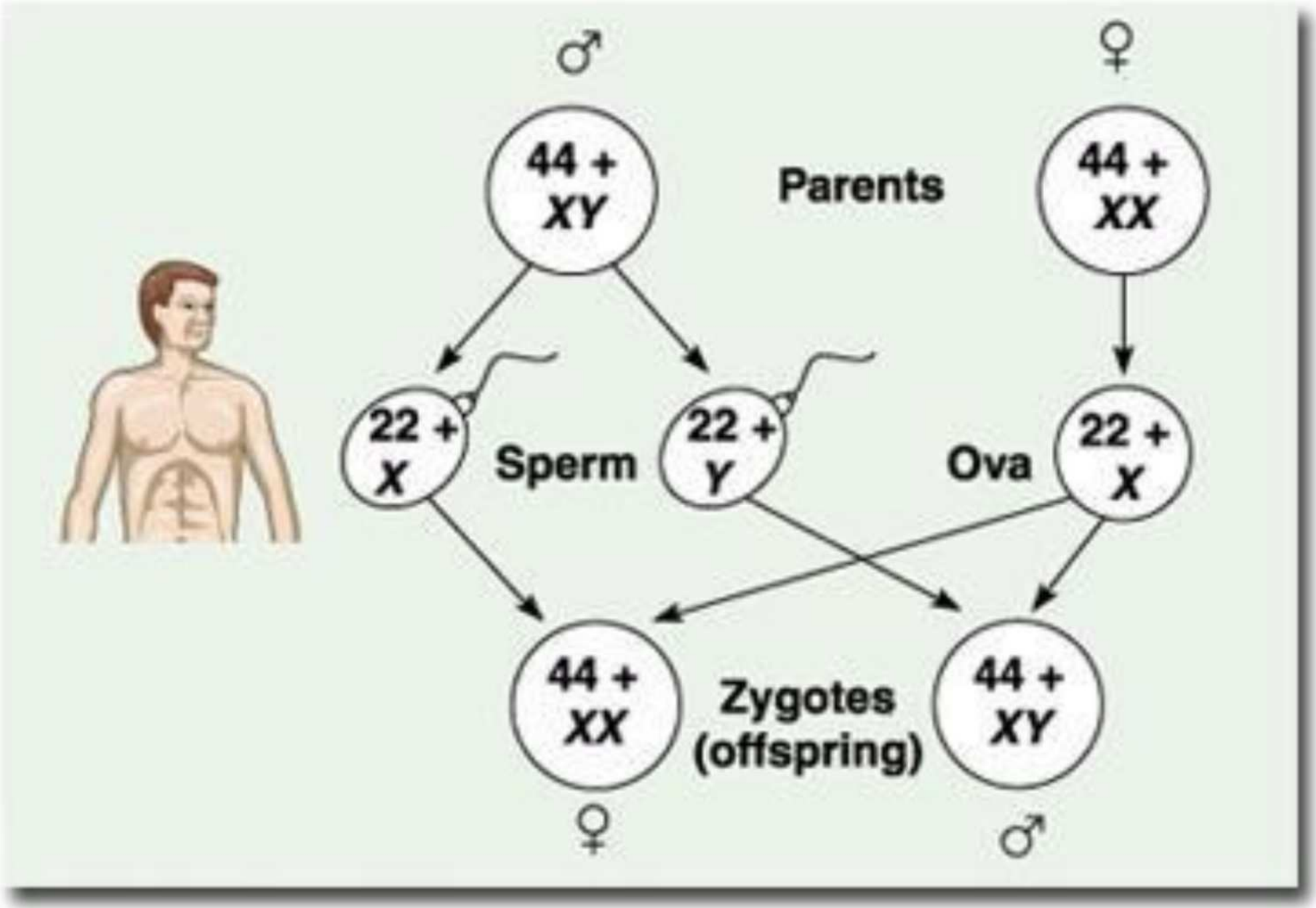

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Fetal nutrition

fetus gets nutrition from mother through placenta.

Umbilical cord is connecting link between placenta and fetus.

PlACENTA

Introduction- Placenta is a spongy cake like structure made up of various layers. Basically it is site of exchange of nutrients and waste material between mother and fetus.

Structure of placenta- Placenta is about 6 inches in diameter (15-20 cm),thickness 3cm and 500 gm in weight.Placenta consist of two parts mainly maternal part and fetal part. In the 12^{th} week the placenta has two portions.

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1. Maternal portion consist of decidua basilis.
2. Fetal portion consist of chorionic villi at mature stage.

Placenta has two surfaces

1. Maternal surface attached to the uterus. The maternal surface is rough and irregular. It is subdivided into a number of lobes called maternal cotyledons.Septa that grow into the intervillous space from the maternal side divide this surface into 15-20 rough and irregular maternal cotyledons.
2. Fetal surface connected to fetus through umbilical cord. **This surface is covered by the fetal membrane amnion and the umbilical cord is attached near the center of this surface.**

Placenta is made up of following layers

1.Cytotrophoblast.

2.Syncytiotrophoblast.

3.Dacidua basilis.

4.Extra embryonic mesoderm forms fetal portion of placenta is called chorion.

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Formation of placenta

Trophoblast layer (Syncytiotrophoblast & cytotrophoblast) develop finger like projections in the endometrium of the uterus is called chorionic villi. Through chorionic villi the oxygen and other nutrient come in the fetal blood.

Function of placenta

1. Exchange of material oxygen and nutrients go to the fetal circulation from maternal blood through placenta. Waste product from fetus return in the maternal blood through placenta.
2. Placenta acts as a barrier because most of the microorgnism can not cross the placenta barrier. Some drug can cross the placenta that may cause adverse effect on fetus.
3. It secretes hormone which maintain the pregnancy.

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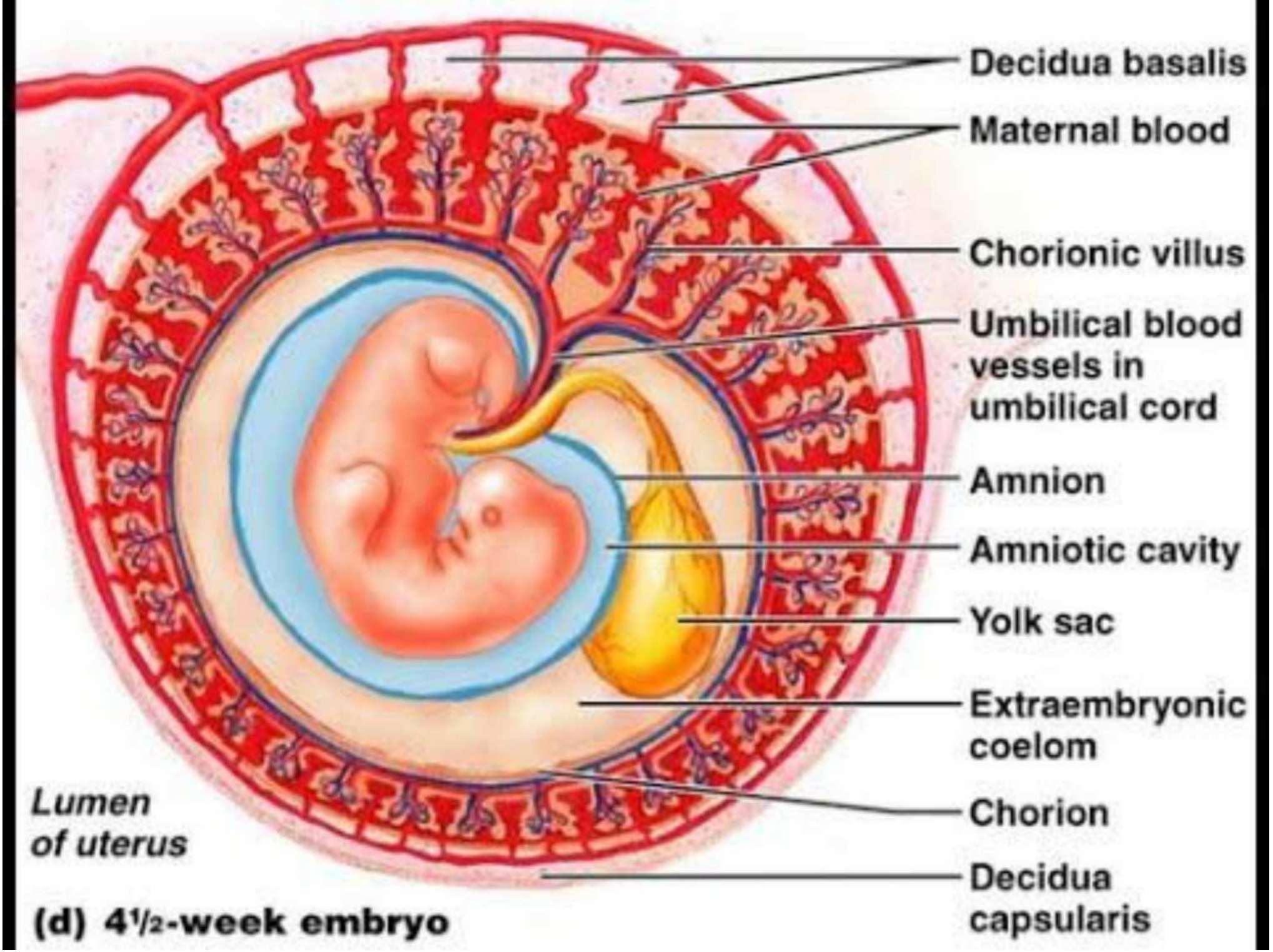

(d) 4½-week embryo

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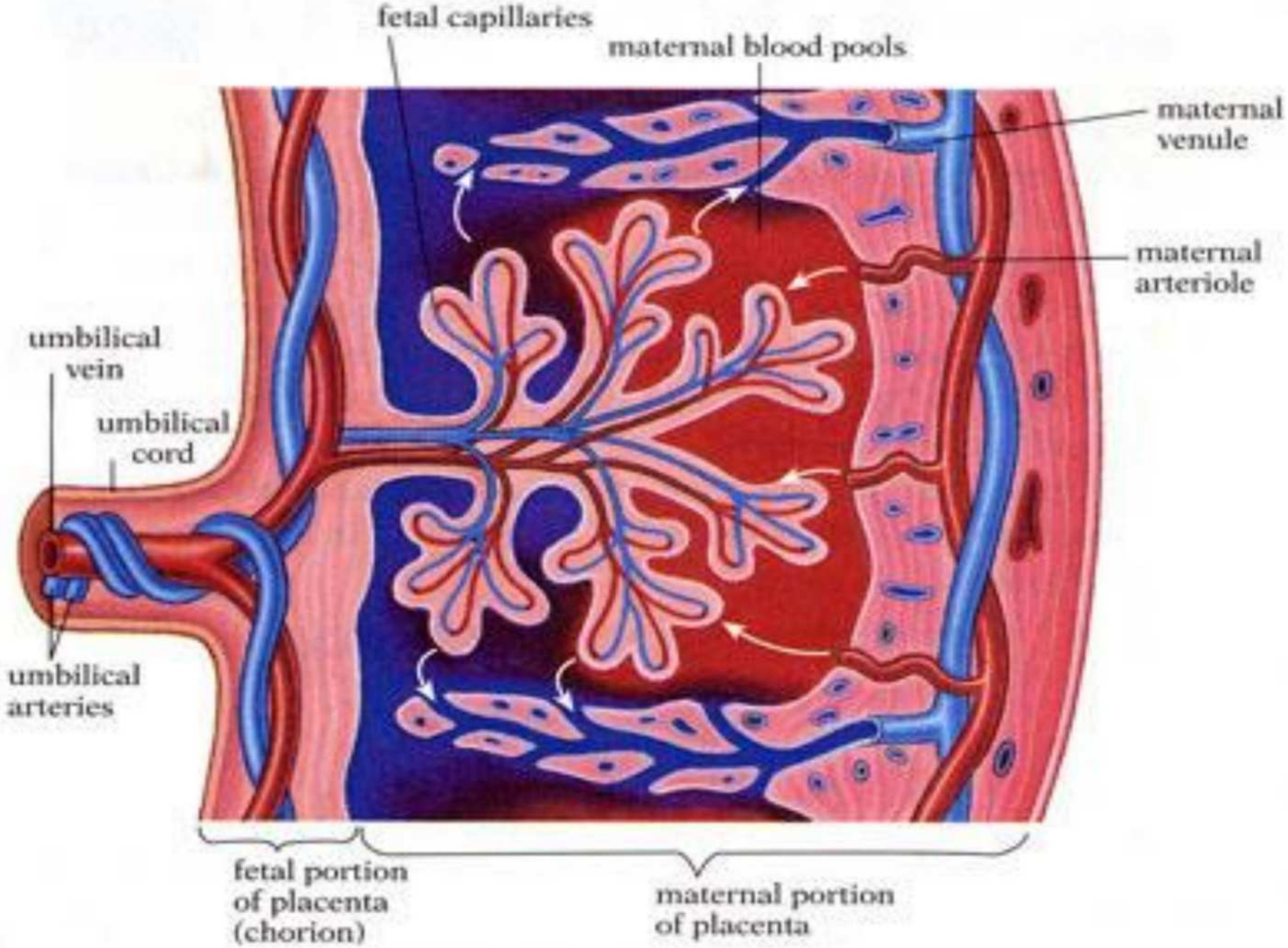

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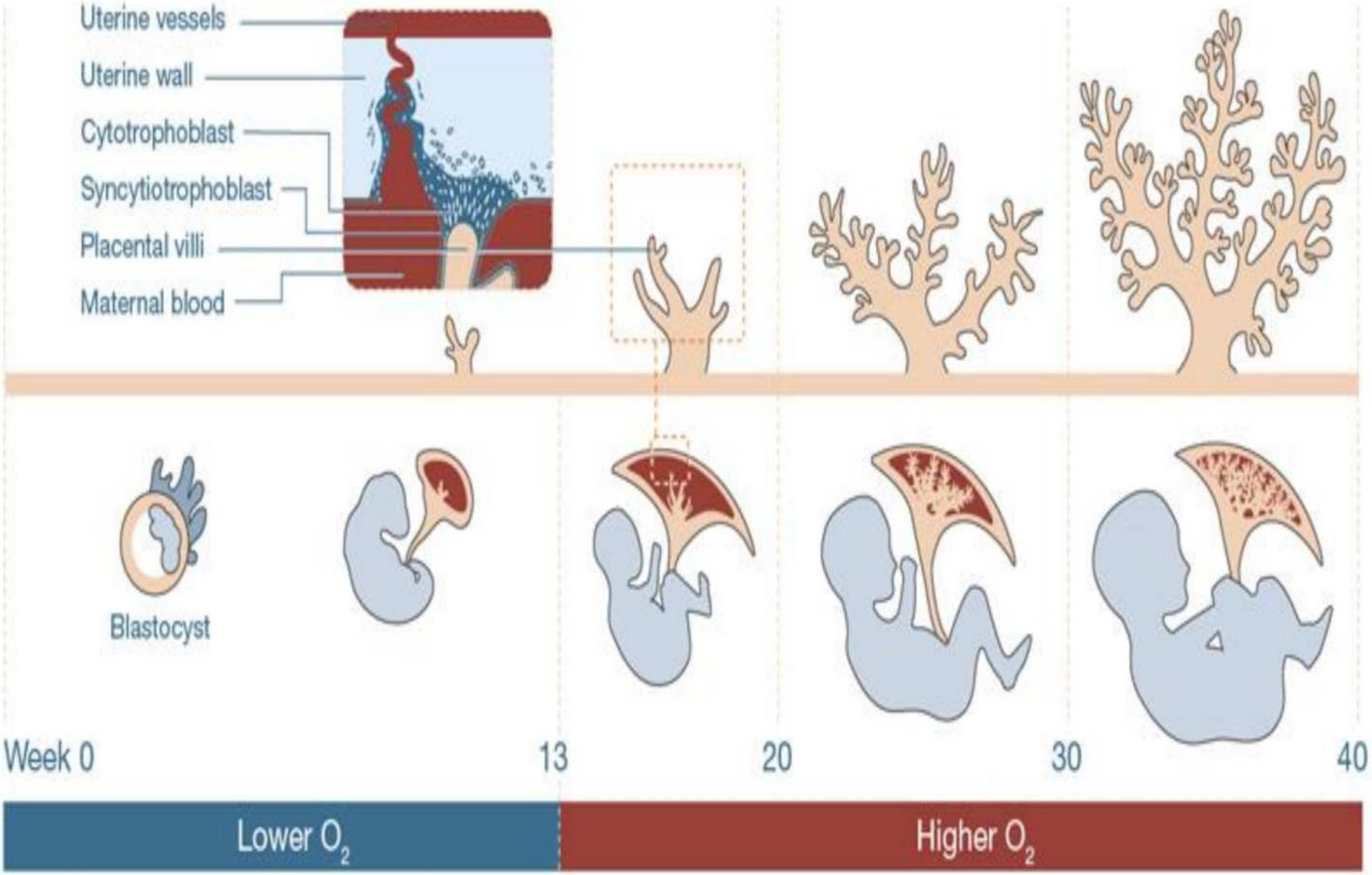
Placental Development: Fertilization to Full Term



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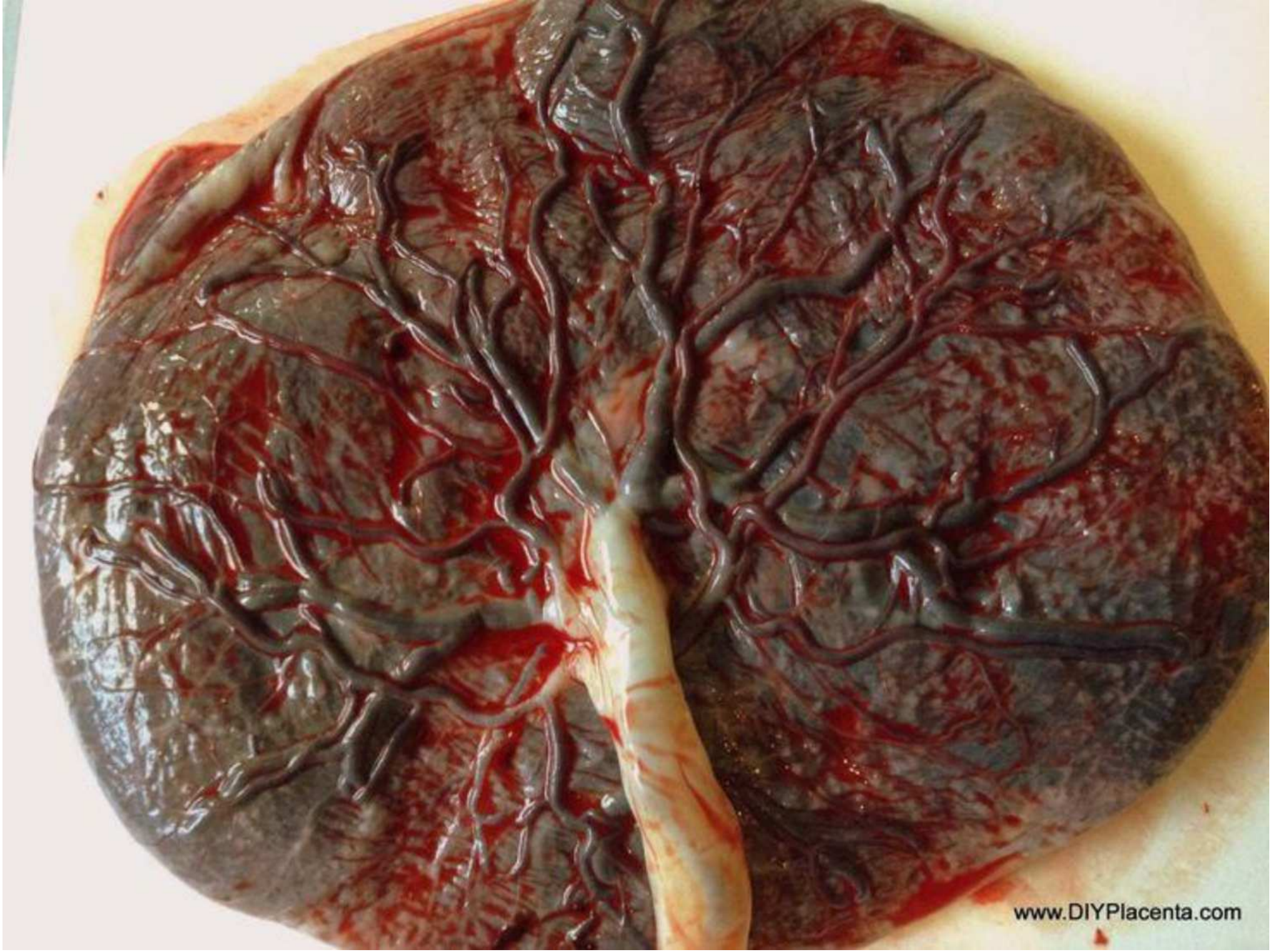

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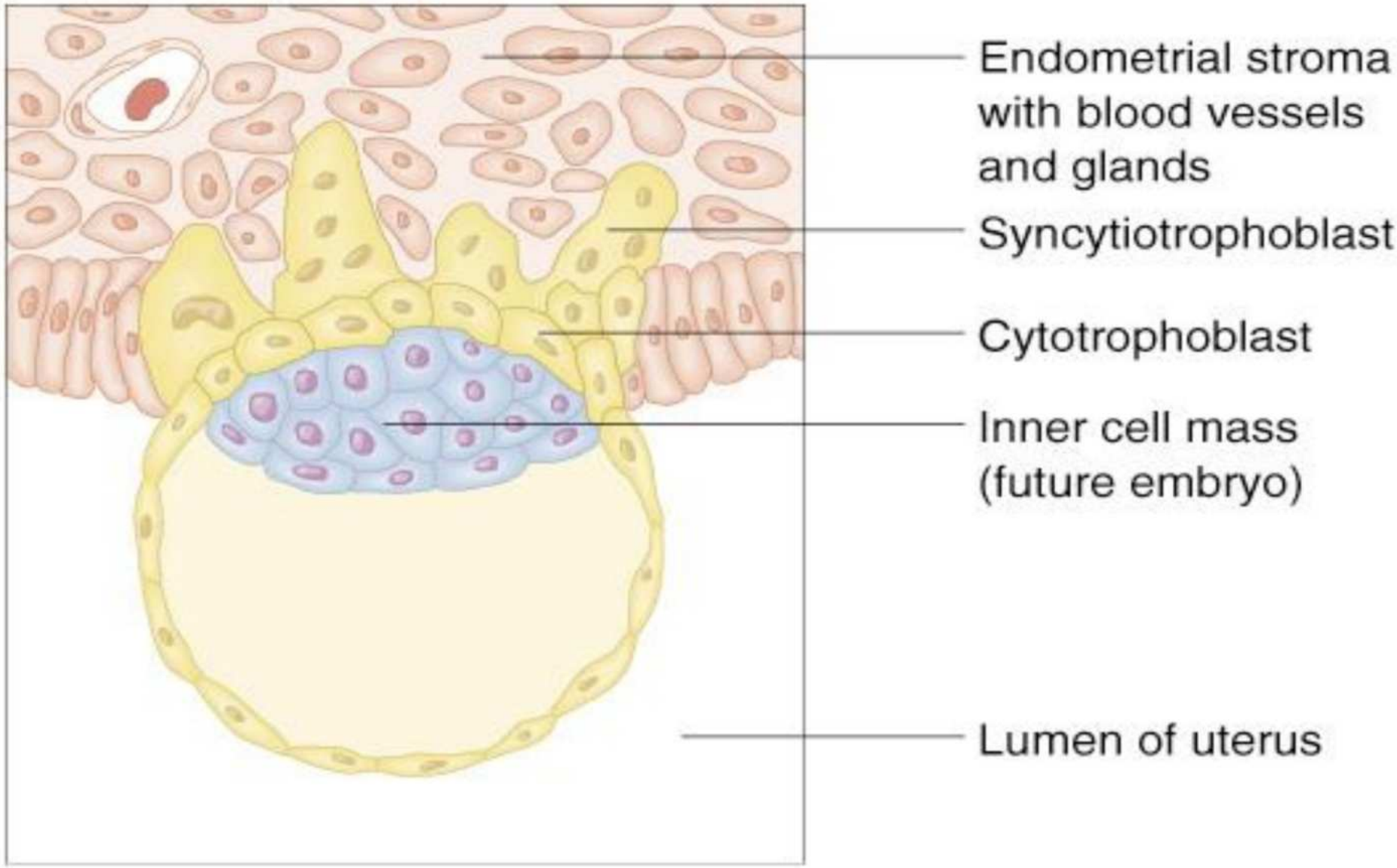

(b)

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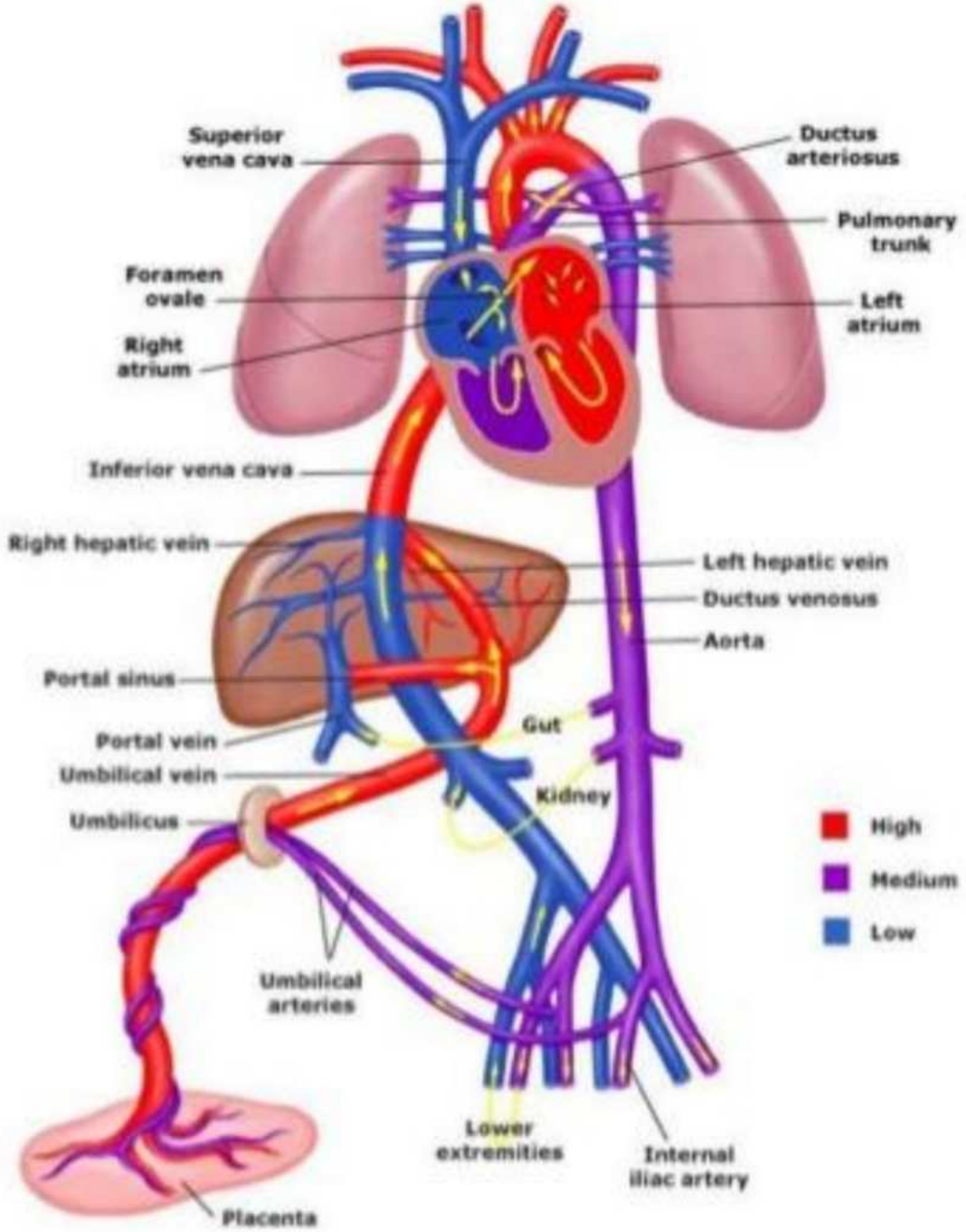

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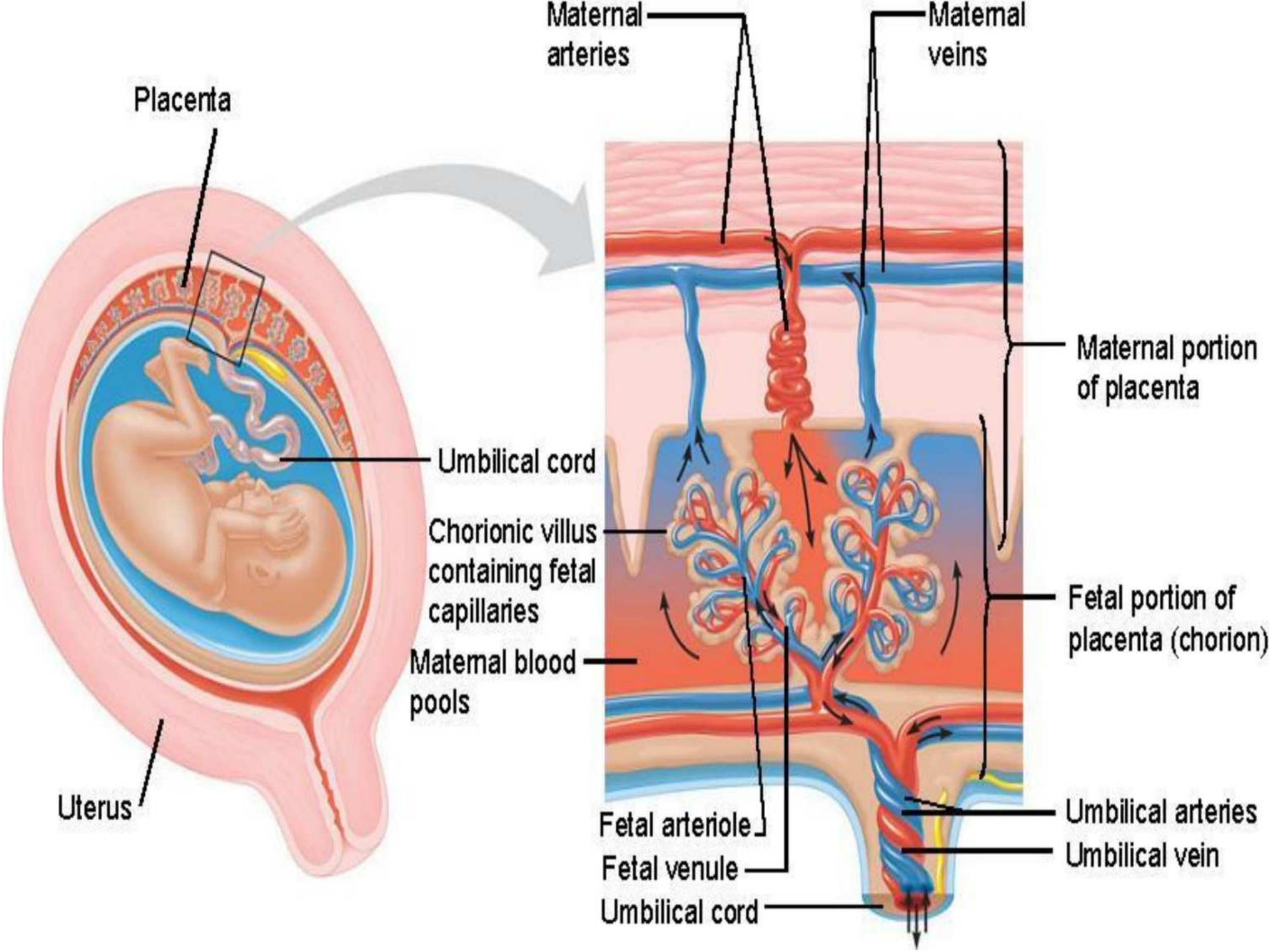

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Placental circulation

In the placeta ,maternal blood circulate through the intervillous space and fetal blood circulates through the blood vessels in the villi. The maternal and fetal blood are flowing side by side in opposite direction they do not mix to each other. They are separated by a membrane, this membrane situated in wall of the villus. Fetal blood always filled in chorionic villi and maternal blood filled in intervillous space. All interchanges of oxygen, nutrition & waste product take place through this membrane.

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Between basal plate and chorionic plate

Intervillous space.

Total Volume- 140 ml.

Maternal blood passing through intervillous space - 500ml/minute.

Volume of fetal blood flowing through fetal villi-400 ml/minute.

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Classification of placenta

Based on shape

1. Discoid- round or disc like.
2. Oval
3. Triangular.
4. Irregular.
5. Lobed

According to attachment of umbilical cord.

1.Normal- central presentation.

2.Marginal placenta- cord is attached to the margin of the placenta.

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Umbilical cord

It is a cord like link between mother and fetus.it is connected between fetal surface of placenta and umbilicus of the fetus.

Components of umbilical cord

It consist of two umbilical arteries and one umbilical vein. Umbilical cord is covered by wharton's jelly. At birth the total length of full term cord is about 50 cm.

Function of umbilical cord

Fetal circulation take place through place umbilical cord.after birth when fetal heart and lungs start functioning independently umbilical cord is cut off. This scar of attachment after birth remains as umbilicus.

After birth umbilical vein convert into ligamantum teres (At the inferior surface of the liver) and umbilical arteries change in to median umbilical ligament.

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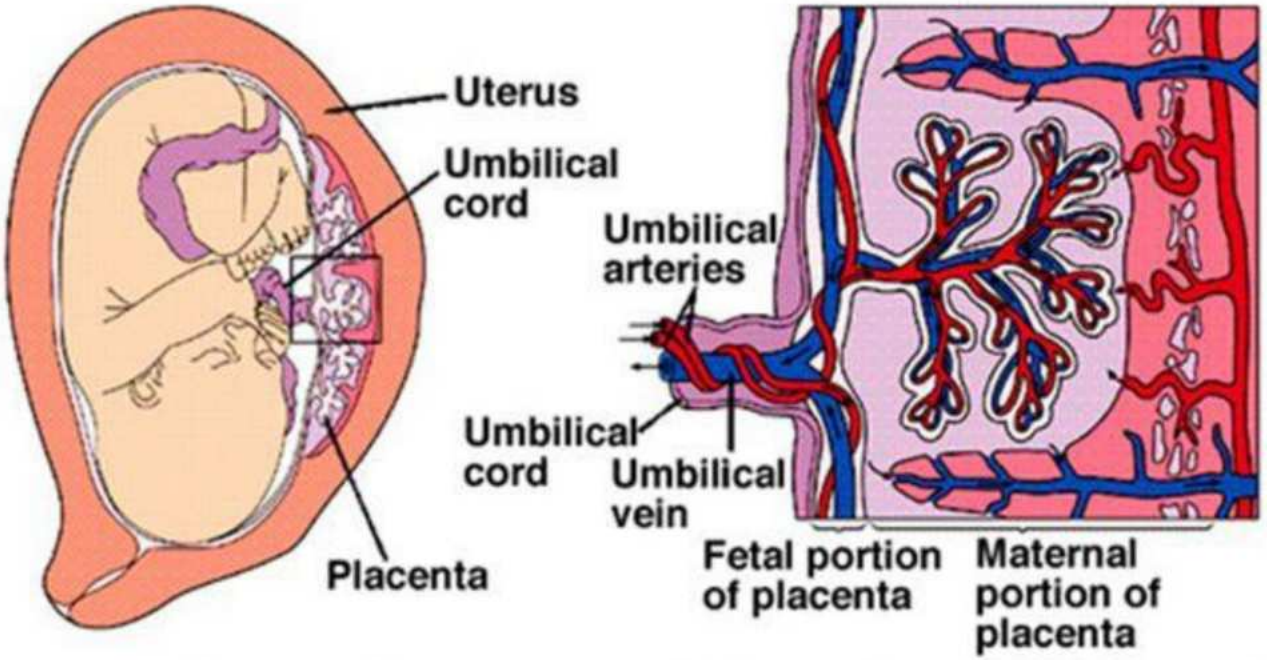
The Placenta and the Umbilical Cord



In the human, the yolk sac and the allantois develop into the ***umbilical cord***. This rope like structure connects the developing fetus to the placenta.

This structure contains blood vessels that transport waste materials out of the embryo's body. Veins inside the umbilical cord carry oxygen and nutrients to the embryo.

★ **(Umbilical cord = vitellus sac + allantois)**

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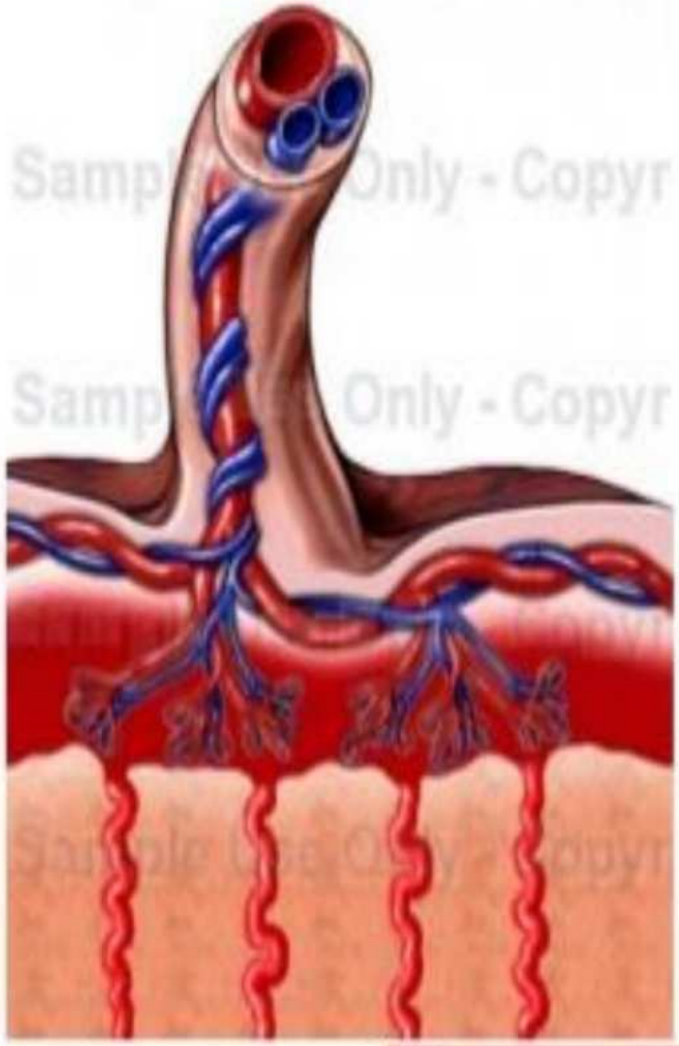
The Umbilical Cord

Structure: It consists of mesodermal connective tissue called Wharton's jelly, covered by amnion.

It contains:

1. One umbilical vein carries oxygenated blood from the placenta to the foetus
2. Two umbilical arteries carry deoxygenated blood from the foetus to the placenta,
3. Remnants of the yolk sac and allantois.



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